A E Fox.

News Chronicle
PRACTICAL MOTORIST'S ENCYCLOPÆDIA

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News Chronicle

Practical Motorist's Encyclopædia

Principles, Upkeep and Repair of Every Part of the Car

WITH 442 ILLUSTRATIONS

BY

C·1930

F. J. CAMM

Editor of "Practical Motorist"

Author of
Encyclopædia of Popular Mechanics, Wireless Constructor's Encyclopædia,
Everyman's Wireless Book, Accumulators, etc., etc.

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PREFACE

THE PRACTICAL MOTORIST'S ENCYCLOPÆDIA—the most complete work of its kind—provides the motorist with a ready means of tracking troubles which may develop in the running of his car, a handy guide to upkeep, overhaul and repair, and, in fact, with a general consultant on motor car practice.

The contents are alphabetically arranged, and include definitions of most of the more important terms used in connection with a motor car. Additionally, important items have been expanded to include practical instruction and diagrams, and in this form the work will be found of value to the mechanic as well as to the owner driver.

My aim has been to provide a handy, well illustrated, and reasonably complete consultant in encyclopædic form. The alphabetical arrangement, it should be noted, renders an index unnecessary, the page headings enabling the particular subject to be consulted immediately.

I have also included at the back of the book useful tables dealing with screw-threads, metric equivalents, and other workshop data.

PREFACE

This volume is a companion work to my *Encyclopædia of Popular Mechanics*, and my *Wireless Constructor's Encyclopædia* (with which it is uniform in size and style), which are obtainable from the same publishers.

I am indebted to the publishers for permission to use many of the illustrations appearing herein, and certain copyright matter.

F. J. CAMM

EDITOR : *Practical Motorist.*

ABBREVIATIONS

A.A.—Automobile Association.
A.C.—Air Cooled and Alternating Current.
A.-C.U.—Auto-Cycle Union.
A.H.P.—Actual Horse Power.
Amp.—Ampere.
B.A.—British Association (Screw Threads).
B.A.R.C.—Brooklands Automobile Racing Club.
B.H.P.—Brake Horse Power.
B.O.T. Unit—Board of Trade Unit.
B.S.F.—British Standard Fine (Screw Threads).
B.T.U.—British Thermal Units.
C.C.—Cubic Capacity or Cubic Centimetres.
Cent.—Centigrade.
Cm.—Centimetre.
C.P.—Candle Power.
D.C.—Direct Current.
D.C.C.—Double Cotton Covered.
Dis.—Disconnection.
D.P.—Double Pole.
D.T.—Double Throw.
E.M.F.—Electromotive Force.
E.V.—Exhaust Valve.
Fah.—Fahrenheit.
H.P.—Hire Purchase, and Horse Power.
H.T.—High Tension.
I.A.E.—Institution of Automobile Engineers.
I.C.—Internal Combustion, and Intermittent Contact.
I.H.P.—Indicated Horse Power.
I.M.T.—Institute of the Motor Trade.
I.V.—Inlet Valve.
J.C.C.—Junior Car Club.
Kilo.—Kilometre.
K.M.H.—Kilometres Per Hour.
Kw.—Kilowatt.
L.T.—Low Tension.
Lum.—Lumens (unit of light).
M.A.A.—Motor Agents Association.
Mm.—Millimetre.
M.P.G.—Miles Per Gallon.
M.P.H.—Miles Per Hour.
M.T.A.—Motor Trade Association.
O.H.C.—Overhead Camshaft.
O.H.V.—Overhead Valve.
P.D.—Potential Difference.
R.A.C.—Royal Automobile Club.
R.Ae.C.—Royal Aero Club.
R.M.S. Value—Root Mean Square Value.
R.P.M.—Revolutions Per Minute.
R.P.H.—Revolutions Per Hour.
R.S.A.C.—Royal Scottish Automobile Club.
S.C.—Short Circuit, Single Contact, and Silk Covered.
S.C.C.—Single Cotton Covered.
S.M.M.T. — Society of Motor Manufacturers and Traders.
S.P.—Series Parallel, and Single Pole.
Sp.G.—Specific Gravity.
S.S.C.—Single Silk Covered.
S.T.—Single Throw.
S.V.—Side Valve, Sleeve Valve, and Slide Valve.
T.P.I.—Threads Per Inch.
W.C.—Water Cooled.
Wh.Th.—Whitworth Threads.

PRACTICAL MOTORIST'S ENCYCLOPÆDIA

A

A.C.—*See Alternating Current.*

ACCELERATION.—The rate of change of speed. It is measured by determining the amount of speed-increase (or decrease) taking place in a given period of time.

It should be noted that, scientifically speaking, the term acceleration applies to a decrease of speed as well as to an increase of speed. Usually, however, when the change of speed is from a higher velocity to a lower one, the decreasing acceleration is termed "negative acceleration," *retardation or deceleration.*

ACCELERATOR.—A device for varying the speed of the engine by regulating the amount of gaseous fuel mixture which is fed to it. Usually comprises a small foot-pedal placed at the driver's feet.

ACCELEROMETER.—A testing instrument used for determining the horse-power developed at the flywheel of a car.

ACCUMULATOR. — A special form of battery into which electrical energy can be fed and withdrawn from at will. Usually comprises a system of specially-prepared lead plates immersed in an electrolyte of dilute sulphuric acid.

ACCUMULATOR INDICATOR.—A name applied to a special form of voltmeter mounted on the instrument board of the car and connected in parallel with the accumulator leads. The instrument usually has a dial which is calibrated, not in volts, but in differently marked or coloured sections which indicate the state of the accumulator's charge.

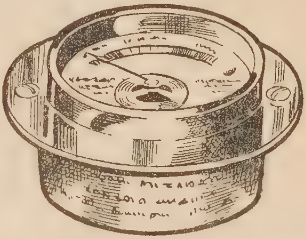


FIG. 1.—A typical Accumulator Indicator.

ACETALDEHYDE. — Chemical formula: $CH_3 \cdot CHO$. A volatile liquid of apple-like odour, traces of which are usually present in the exhaust gases of engines running on alcohol fuels.

ACETIC ACID.—Chemical formula: $CH_3 \cdot COOH$. An organic acid forming the basis of vinegar. It occurs in the exhaust gases of engines running on alcohol fuels. If present in more than small amounts, it sets up a corrosion of the metal parts.

ACETONE.—Chemical formula: $CH_3 \cdot CO \cdot CH_3$. A highly-inflammable liquid with a peculiar pungent odour. Mixed with amyl acetate it forms a powerful solvent for celluloid. It is an ingredient of celluloid cements.

ACETYLENE.—Chemical formula: C_2H_2. A colourless hydrocarbon gas, poisonous, and of characteristic odour. It was at one time employed for car lighting and is now occasionally used as a dope for enriching alcohol fuels.

ACID.—Applied to motoring, this term usually denotes the electrolyte (dilute sulphuric acid) in the accumulator.

ACKERMAN SYSTEM. — The steering system used nowadays. It comprises a front axle which is firmly fixed at right angles to the frame. At each side are mounted movable steering-heads connected together by a cross-rod. This construction results in both front wheels of the car being moved simultaneously by the motion of the steering wheel which would not be the case if the front axle were merely pivoted centrally underneath the car. The Ackerman system gives a satisfactory " lock " or turning-circle to the front wheels.

The system is really the invention of Lankensperger, of Munich, in 1819, Herr Ackerman having merely acted as a patent agent in this country at a later date.

ADAPTER.—A device or fitting for joining two parts of different sizes together.

ADIABATIC.—A theoretical term, used in connection with energy and heat calculations, which implies " without heat-loss."

ADJUSTABLE SPANNER.—Name given to a spanner the jaws of which are capable of easy adjustment to enable them to fit nuts of varying sizes.

ADVANCED IGNITION.—Term used to describe the setting of the ignition-timing of the engine so that the spark occurs at the plug points before the piston reaches the top of its stroke. Synonym : Early Ignition.

AFTER-FIRING.—The state of an engine running after the ignition has been switched off. Due, usually to the presence of incandescent or glowing particles of carbon on or around the plug electrodes.

AIR.—The invisible mixture of gases surrounding the earth and upon the presence of which all life and combustion depends. An average sample of pure air contains approximately 23 parts of oxygen and 77 parts of nitrogen, together with smaller amounts of other gases and varying quantities of water-vapour.

See *Oxygen, Nitrogen.*

AIR-BOUND.—See *Air-Lock.*

AIR-BRAKE.—An engine horsepower testing device comprising a revolving fan which pumps air at high speeds over the engine under test. The engine tends to twist in a direction opposite to that of the fan, the degree of its twisting-tendency being measured. This corresponds to the actual horsepower which the engine develops. The arrangement is known, technically, as the Heenan-Fell brake.

AIR COOLING.—A term referring to the method of dispersing the heat produced in the cylinders of the engine. Though capable of being applied to multi-cylinder engines for road-use, air-cooling, in practice, is only employed for light-car engines of the opposed twin-cylinder pattern.

AIR DYNAMOMETER. — See *Air Brake.*

AIR-FILTER. — An air-filtering device consisting of an arrangement of fine metal gauze which is fitted to the air-intake of the carburettor in order to prevent road dirt, dust and grit from obtaining access to the interior of the cylinders.

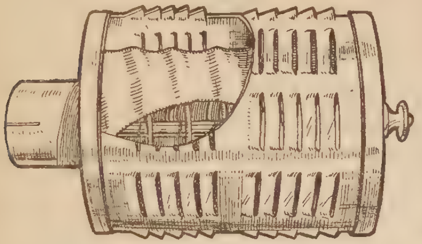


FIG. 2.—One Type of Air-Filter.

AIR INTAKE.—The port or orifice through which the air supply to the carburettor is drawn.

AIR LOCK.—Stoppage effect caused by an accumulation of air in a pipe conveying a liquid. Air-locks may sometimes occur in the petrol or radiator systems of a car.

AIR PRESSURE.—Term usually denoting the pressure of air within the inner tube of a pneumatic tyre. Tyre manufacturers publish a table of air pressures. This should be consulted in case of any doubt as to the correct air pressure required within any particular tyre.

AIR-PRESSURE GAUGE. — A pressure - measuring instrument, which, when attached to the tyre valve, indicates the air pressure inside the inner tube.

It should be noted that pressure gauges which are attached to the air pump of a tyre do not show the actual air pressure within the tube, but mainly the pressure at which air is being pumped into the tube.

AIR-SCREW.—A milled head screw fitted to some jet-type carburettors as an extra means of regulating the mixture-strength, usually for slow-running purposes.

AIR-TUBE.—The inner rubber tube of a pneumatic tyre in which air is compressed.

AIR VALVE.—A valve for admitting extra air to the gaseous fuel mixture of the engine.

The term is also applied to the non-return valve which admits air into the inner tube of a pneumatic tyre.

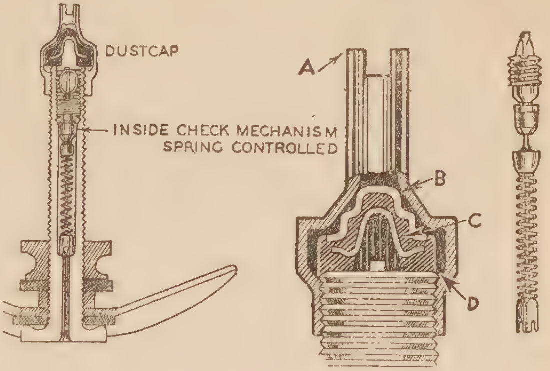


FIG. 3.—Section of a Schrader Valve, Cap and Centre.

ALCOHOL.—Term usually applied to the colourless, volatile and inflammable liquid produced by the fermentation of sugars. Can be employed alone or in admixture as a motor fuel.

ALDEHYDE.—See *Acetaldehyde.*

ALIGNMENT.—The arrangement of parts in true line with one another.

ALIPHATIC HYDROCARBONS.—Term used in fuel technology to denote hydrocarbon liquids, such as ordinary petrol, which are made up of paraffin-like constituents. They are also known as " Paraffin hydrocarbons."

ALLOY.—An intimate mixture of two or more metals. Notable alloys used in car construction are Nickel-Steel, Chrome Steel, Phosphor-Bronze, Brass, etc.

ALLOY STEELS.—General term given to a large class of steels which contain varying percentages of other metals. Such steels have properties peculiar to themselves and are therefore employed for specialised purposes.

See *Nickel Steel, Stainless Steel, Tungsten Steel,* etc.

ALTERNATING CURRENT. — Electric current which flows backwards and forwards along a conductor in rapid alternation. Cannot be used for car-battery charging unless it is rectified beforehand by passage through a rectifier. Abbreviation: *A.C.*

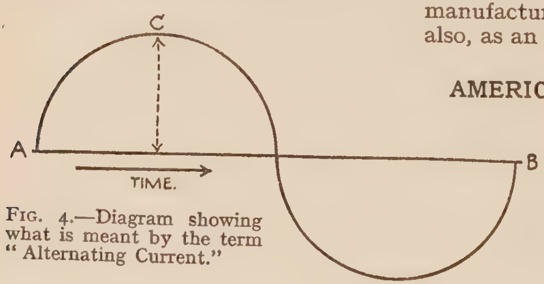


Fig. 4.—Diagram showing what is meant by the term " Alternating Current."

ALTERNATIVE FUELS.—Fuels other than petrol which can be used for the running of cars. Of these, the best known is benzole. Other alternative fuels are alcohol, pure and in admixture, heavy oils, naphtha, creosote and various inflammable gases.

ALUMINIUM. — A bluish-white metal, capable of taking a high degree of polish. Owing to its lightness, its ductile and malleable nature, its cheapness and the readiness with which it is cast, aluminium and its alloys form very important car constructional materials. Pure aluminium melts at 657 degrees Centigrade. It has a specific gravity of 2·6, this being one-third of the Specific Gravity of Iron.

AMALGAM.—An alloy containing mercury. Amalgams have been used in certain car-engine temperature-recording devices.

AMBROIN.—A resinous material composed of silicates mixed with colap resin. Used sometimes in the manufacture of car fittings and, also, as an insulator.

AMERICAN THREADS.—Name given to an American series of standard screw-threads having a cross-section similar to the Metric threads. They are sometimes known as " Seller's Threads."

AMMETER.—An instrument which measures the amount of current flowing in an electrical circuit. On a car it is generally used for indicating the amount of current flowing in and out of the battery.

AMP.—See *Ampere.*

AMPERE.—The unit of electrical quantity. A current of 1 ampere flows when an E.M.F. of 1 volt is applied to a conductor having a resistance of 1 ohm. Abbreviation: *Amp.*

(After *Audre - Marie Ampere,* French electrician, 1775-1836).

AMPERE-HOUR.—The practical unit of quantity of electricity. Abbreviation: *Amp.-hour.*

One amp.-hour is the quantity of electricity represented by a current of one ampere flowing through a circuit for one hour. The term is used largely in connection with accumulator discharge-rates.

AMPEREMETER. — See *Ammeter.*

AMYL ACETATE. — Chemical formula: $CH_3 \cdot CO \cdot C \cdot {}_2H_{11}$. A colourless, inflammable liquid with a strong pear-drop odour. Mixed with acetone it is a solvent of celluloid and is an important ingredient of the many celluloid cements used for repairing celluloid screens and other articles of the same material.

ANGLE OF LOCK.—See *Steering Lock.*

ANNEALING.—Name given to a system of heat-treating metals and other materials whereby they are made softer and more readily workable.

Annealed metals are often changed in physical and electrical properties.

ANTI - FREEZE. — Substances, such as glycerine and calcium chloride, which are sometimes added to the radiator water of a car in order to lower the freezing-point of the liquid.

ANTI-FRICTION BEARING. — Special type of bearing which reduces frictional effects to a minimum.

ANTI-FRICTION METAL. — A lead-antimony alloy of similar composition to White Metal (which see). As it forms a very fine and smooth surface, it is often used for the lining or bushing of bearings on account of the ease with which it can be accurately surfaced to make a perfectly true and even bearing.

Anti-friction metal bearings must be most adequately lubricated, otherwise the heat generated will quickly melt the alloy.

ANTI-KNOCKS. — The name given to certain chemicals which when added in small amounts to petrol fuels prevent the development of knocking in engines run on those fuels.

See *Lead Tetraethyl,* etc.

ANTI-KNOCK VALUE. — Term applied to denote the degree of freedom of a motor fuel from detonation or knocking.

ANTI - SULPHURIC PAINT. — Paint containing Burgundy pitch, asphaltum, raw rubber, etc., which is sometimes applied to the tops of car batteries and occasionally to other parts in order to prevent corrosion by acid.

ARBOR.—An axis or spindle on which a wheel revolves.

ARBOR SHAFT.—The shaft along which power is transmitted from the car gearbox to the back axle.

ARCING.—Terms used to denote the passage of an electric spark between two surfaces, usually between switch contacts, magneto contact-breakers, etc.

ARGENTAN.—A name for nickel silver resistance alloys.

See *Nickel Silver.*

ARMATURE.—The inner rotating part of a magneto or dynamo.

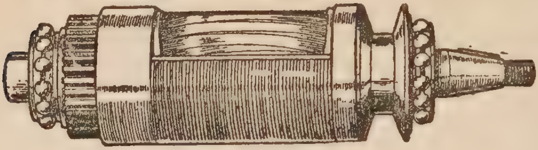


Fig. 5.—A typical Magneto Armature.

Consists essentially of coils of insulated copper wire specially wound over an iron centre.

ARMATURE TUNNEL.—A name sometimes applied to the space existing between the poles of magneto or dynamo magnets in which the armature revolves.

ARMOURED WIRE.—An insulated conductor possessing an external protective covering of metal. Used often in car wiring.

ARTILLERY WHEEL.—A type of road wheel originally designed for gun-carriage use, but now employed in varying patterns on cars on account of its resistance to shocks and strains.

Essentially its features comprise a long bearing surface for the axle, and, usually, a " dishing " outwards of the wheel—*i.e.*, a bending outwards of the centre of the wheel so that an imaginary vertical line passing through the tyre does not pass through the hub. Sometimes, however, the wheel may be constructed without any " dish " the axles being bent down very slightly to conform with the bend of the road surface.

ASBESTOS.—A fibrous heat-resisting mineral much used for insulating purposes, for brake-lining compositions and for the making of washers and packings for joints. It contains approximately 40 per cent silica, 43 per cent magnesia and up to 3 per cent each of iron and aluminium, the remainder being water.

ASPHALTE ASPHALTUM. — A naturally - occurring pitch-like mineral. It forms the basis of many insulating materials which are used to protect wiring cables on cars. Natural asphalte is only one ingredient of the various road-surfacing materials bearing the same name.

AUTOMOBILE.—Literally, a self-moving contrivance, the term being now exclusively applied to road cars.

From the Greek: *Autos*, self; Latin, *mobilis*, mobile.

AUTOVAC.—An auxiliary fuel tank, usually fitted near to the engine, which by a method of suction, takes fuel from the main tank of the car and delivers it under the influence of gravity to the carburettor.

See *Vacuum and Gravity Supply*, also *Fuel Feed Systems*.

AUTOVOX HORN.—An old type of motor-horn, working on the reed principle, the current of air for which was derived from a flywheel-operated pump.

AUXILIARY SPRINGS. — Term sometimes used to denote small but strong coiled springs, often enclosed in casings, which are attached to the rear portions of the leaf-springs of a car in place of spring shackles. They are also termed " Secondary Springs."

AUXILIARY TANK. — A fuel tank fitted to the car enabling small quantities of petrol to be reserved for test or emergency purposes.

AXLE CASING. — The hollow tube or casing between the rear wheels of a car. It encloses the entire rear axle assembly.

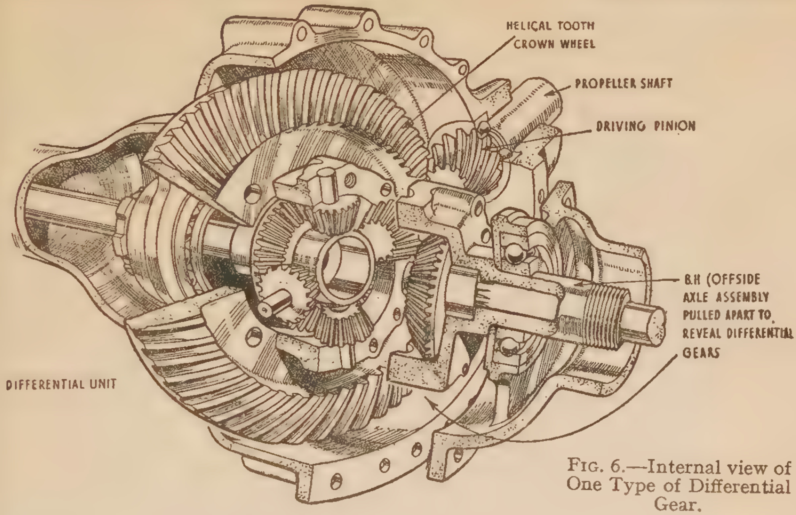

HELICAL TOOTH CROWN WHEEL
PROPELLER SHAFT
DRIVING PINION
B.H (OFFSIDE AXLE ASSEMBLY PULLED APART TO REVEAL DIFFERENTIAL GEARS
DIFFERENTIAL UNIT

Fig. 6.—Internal view of One Type of Differential Gear.

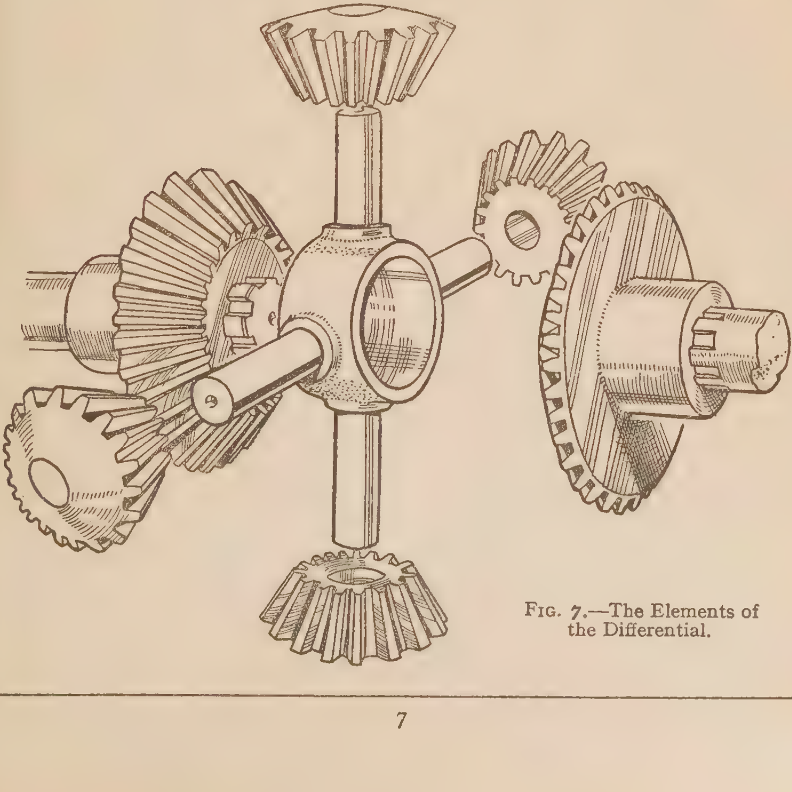


Fig. 7.—The Elements of the Differential.

B

BACK AXLE.—The complete unit which carried the rear wheels of the car. It comprises the axle casing, the power shaft, the bevel and the differential gear.

Synonym : *Rear Axle.* See also *Differential.*

Overhauling the Back Axle.—Noise is usually the first symptom of trouble in the back axle. Whilst the worm drive axle is admittedly the quietest form of transmission, the bevel drive axle, if it is in good order, should be practically inaudible in use. Extensive wear results in the bevel wheel and pinion getting out of correct mesh, this gives rise to a humming or grinding noise in the axle according to whether the wear has allowed the wheels to get too far out, or in, mesh, respectively. Sometimes the first indication of axle trouble is found when the car is jacked up for some purpose, when extensive " play " is found to exist.

Examination.—Noise is by no means always present with rear axle wear. Axles, which on inspection have been found in very bad condition indeed, have given no indication by noise of their condition. Usually the damage caused by accidents is visible, but frequently a smashed ball or race, or a slightly bent shaft or axle tube will escape notice for some time, until perhaps very extensive damage has resulted. In all cases where axle damage is suspected, it is advisable to make a most thorough examination before passing the axle as satisfactory. The procedure should be as follows : First jack up the car under the rear axle so that both rear wheels are off the ground, scotching the front wheels on both sides so that the car cannot move or " jump " the jacks. Then run the engine, and with the brakes off engage the bottom gear and allow the back wheels to run. It is better to notice the edges of the rims, as it is possible for the tyres to " run out " quite a lot, especially those of the " well-base " variety. If a bad wobble is found in a wheel it is necessary to test to see whether the wheel only is damaged and out of truth, or if the axle shaft or tube is bent. An easy means of testing the truth of the wheel is to nail a strip of wood to a small box or block of wood, and bring this up to the edge of the rim. Turn the wheel by hand and note if the rim keeps the same distance from the wood pointer throughout the whole of its revolution. Rims are seldom " dead true," and a margin of $\frac{1}{16}$th inch should be allowed. These remarks apply to wheels of the pressed steel type, either spoked or dished or disc wheels. If the wheel shows considerable wobble, it should be removed and replaced by another in the same way. If this wheel runs true, then it is the first wheel and not the axle shaft which is bent, but if both wheels wobble, the matter is more serious, and the axle shaft must be examined. In many cars, mostly of American manufacture, wood wheels with detachable rims are fitted. These rims are never true, so any test should be applied to the wood felloe of the wheel. If both wheels are found to run true after test, and there is no noise in the axle when run on the road, it is not likely that there is any damage requiring attention. It is, however, advisable to look over all the connections to the axle. Likely points of damage are : axle driven along springs. In this case the centre bolt of the spring will probably have sheared, but the

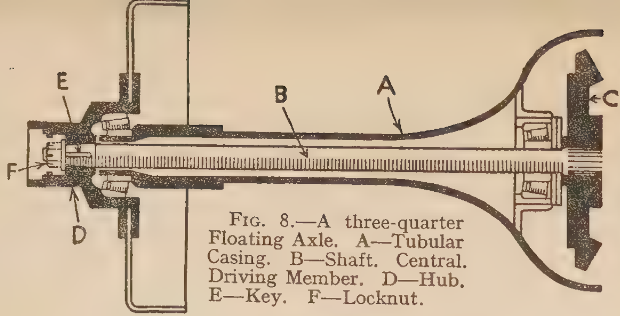


FIG. 8.—A three-quarter Floating Axle. A—Tubular Casing. B—Shaft. Central. Driving Member. D—Hub. E—Key. F—Locknut.

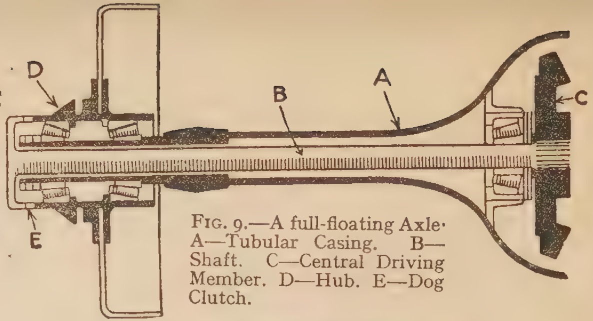


FIG. 9.—A full-floating Axle· A—Tubular Casing. B—Shaft. C—Central Driving Member. D—Hub. E—Dog Clutch.

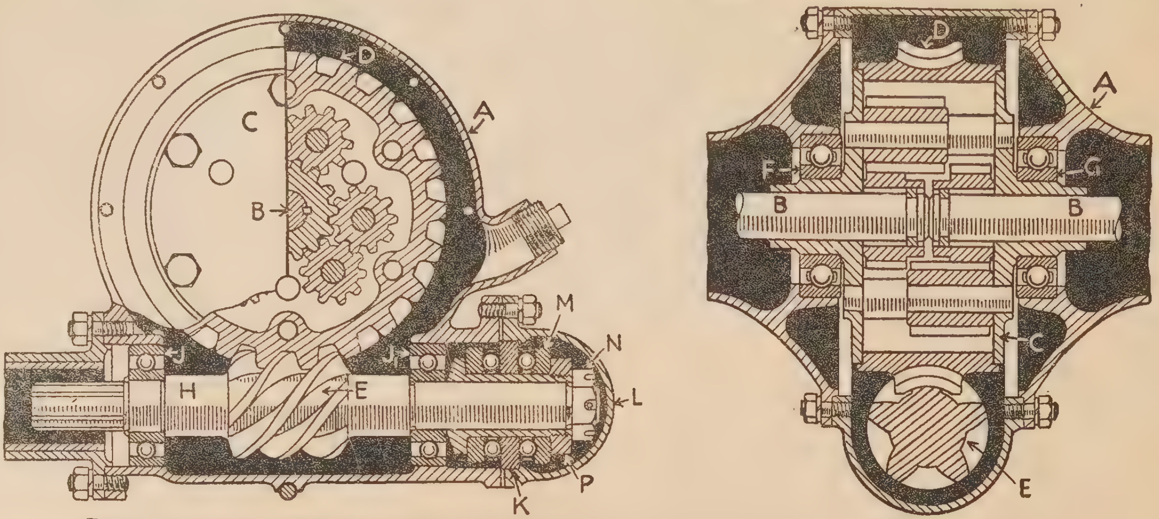


FIG. 10.—Sectional Drawings showing the components of a Worm-drive Back Axle. A—Axle Casing. B—Drive Shaft. C—Differential Gear Box. D—Worm Wheel. E—Worm Drive. F & G—Bearings. H—Worm Shaft. J & J1—Ball Bearings. K—Thrust Bearing. L—End Cap. M—Ball Race. N—Lock Nut. P—Collar.

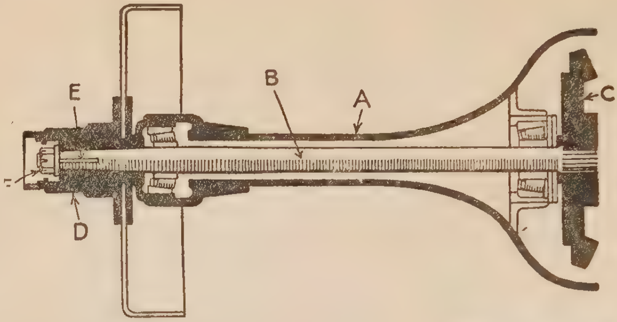


FIG. 11.—Semi-floating Rear Axle. A—Tubular Casing. B—Shaft. C—Central Driving Member. D—Hub. E—Key. F—Locknut.

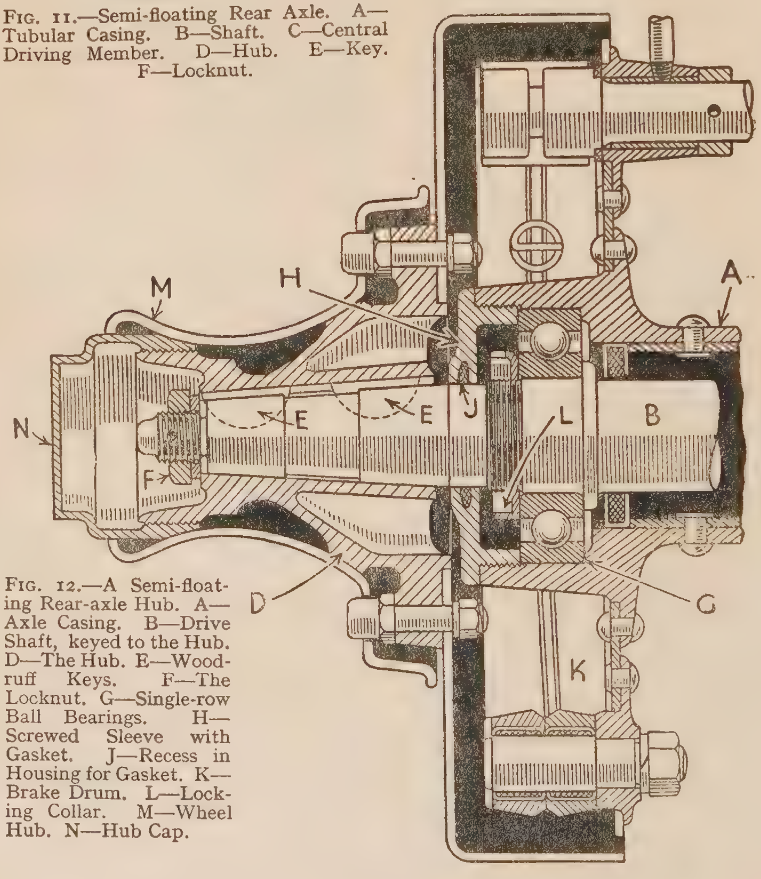


FIG. 12.—A Semi-floating Rear-axle Hub. A—Axle Casing. B—Drive Shaft, keyed to the Hub. D—The Hub. E—Woodruff Keys. F—The Locknut. G—Single-row Ball Bearings. H—Screwed Sleeve with Gasket. J—Recess in Housing for Gasket. K—Brake Drum. L—Locking Collar. M—Wheel Hub. N—Hub Cap.

BACK AXLE DETAILS

A—Axle Casing. B—Drive Shaft. C—Differential Gear. D—Crown Wheel. E—Bevel Pinion. F & G—Ball Bearings. H & H1—Screwed Adjusting Sleeves. J—Cover. K & K1—Locking Clips.

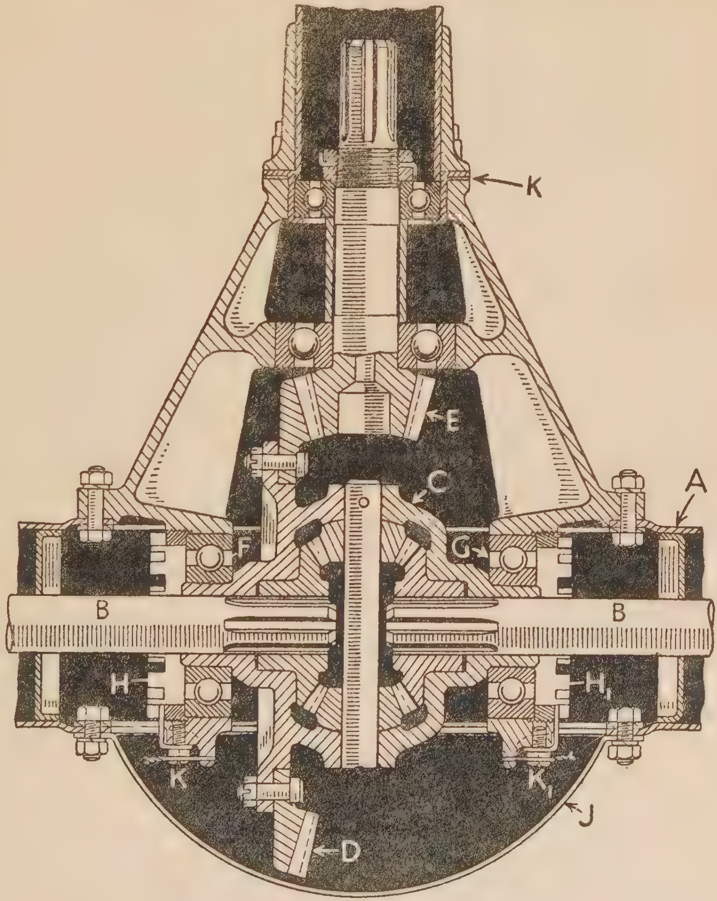


Fig. 13—The above Drawing shows the arrangement of a Bevel-driven Axle.

position of the spring clips will show if axle has moved on the springs.

Complete absence of external damage indications to the axle and its connections does not prove that no damage has been sustained, but forms a sufficient safeguard to pass the axle for further service if there is otherwise no reason for taking it down. Recent looking cracks in paint, or oil leaks round brazed or riveted joints should all receive the closest attention, as a cracked axle tube or case may give no other sign until it actually fails through breakage.

Removing the Differential.—This is a messy job, and before removing it the oil should be drained from it and it should be flushed out with paraffin. Run the back axle whilst jacked up to make sure that all the oil is drained out. The method of detachment will depend on the make of the car, and is obvious on inspection. It will, of course, be necessary to draw the two rear half-axle shafts, and in most cases the differential unit can then be lifted out complete for examination. Whilst the half-shafts are out examine the wheel bearings, which not infrequently have broken rollers. Remove all of the inner bearings and make quite sure that there are no worn races and no play. All of the races may be obtained locally.

BACK-FIRE.—Term which usually denotes an explosion in the silencer or in some other part of the engine's exhaust system.

It is mainly due to the use of too weak a mixture or to some fault in the ignition timing, whereby the charge is not normally exploded in the cylinder but forms accumulations of unburnt gas in the exhaust system. These are fired by the heat of the exhaust system or by the hot gases ejected from the cylinder.

It is sometimes termed " Popping," and, also (though not strictly correctly), "Misfiring."

BACKLASH. — The degree of " play " or individual freedom existing between two or more pinions in a wheel-train.

Applied to the steering control of a car, the amount of backlash present is indicated by the extent to which the steering wheel can be rotated without influencing the front wheels of the car. A certain amount of steering backlash should always be present.

BACK PRESSURE.—The pressure exerted on the piston during its exhaust stroke by the exhaust gases when they are not allowed a sufficiently free escape from the exhaust system.

BAFFLE : BAFFLE-PLATE.—A plate or sheet of metal which breaks up a stream of heated gases.

These terms are usually applied to metal plates which are sometimes included in the silencers of cars in order to break-up the current of exhaust gases and thus to diminish the sound of their uninterrupted passage to the outer air.

BAKELITE.—A name given to a class of synthetic resinous materials —although, strictly speaking, it only applies to one particular resin —produced by the interaction of formalin and carbolic acid.

Bakelite resins and similar materials are much used in the construction of instrument components, car fittings, etc. They are good insulators, non-inflammable, weatherproof, cheaply produced and are easily moulded to any shape or form. Hence the increasing popularity of these materials.

From *L. H. Baekeland* who in 1908, filed important patents for the manufacture of these products.

BALANCE CRANK.—A crank having a balance weight opposite to its cranked portion, its function being to enable the piston more readily to overcome the stopping tendency which it experiences at the end of each stroke.

BALANCE GEAR. — See *Differential Gear.*

BALL BEARING.—A bearing in which rows of hardened steel balls are interposed in channels or "races" between the rotating and the stationary surfaces of a bearing. A properly-constructed ball-bearing is almost frictionless.

BALL JOINT.—A joint in which a ball on the end of a rod or lever moves in a socket provided in another member, thus providing for movement in different directions.

BALLOON TYRES.—Tyres of large cross-section containing air at relatively low compression. They minimise vibration and road-shock.

B.A. THREADS.—British Association threads. A range of screw-threads standardised by the British Association and used extensively in electrical instrument making, such as dynamo and magneto construction, and sometimes in very fine engineering work.

B.A. threads have angles and curves which are quite different from those of the Whitworth series of threads. Their dimensions are always stated in millimetres and their sizes are numbered consecutively from No. 0 to No. 25, the former number representing the thread with the largest diameter.

BATTERY.—The term by which car-users denote the accumulator or storage-battery of the car.

BATTERY ELECTRODE. — See *Electrode.*

BATTERY-IGNITION.—See *Coil-Ignition.*

BEADED-EDGE TYRE.—Outer cover of pneumatic tyre which is provided with a hard edge or "beading" to fit into a channel at each side of the wheel rim.

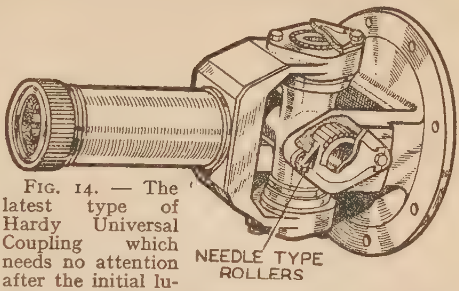


FIG. 14. — The latest type of Hardy Universal Coupling which needs no attention after the initial lubrication. Note the needle rollers and oil reservoir.

BEARING.—The part of aperture in which a spindle or shaft revolves. Bearings are commonly of three types: Plain, Ball and Roller-bearings.

BELT.—A continuous strap or band of leather or some other flexible material, jointed or unjointed, the function of which is to transmit power from one pulley to another.

BELT DRIVE.—A now obsolete means of transmitting power from the engine to the countershaft by means of a flexible belt. Early cars were often fitted with belt drives.

BENDIX BRAKE.—Name applied to a modern car-braking system. In the brake drums there are two brake-shoes, a primary shoe and a secondary shoe. When the brake lever is applied, the primary shoe makes frictional contact with the interior of the brake drum. Since this is revolving, it tends to cause the primary shoe to revolve with it. The movement of the primary shoe which is thus set up is caused to influence the secondary shoe which is then brought into operation. The shoes are forced apart into closer contact with the interior of the brake drum.

Adjusting Bendix Brakes.—Many modern cars are fitted with the Bendix Duo-Servo brake system the method of adjusting which is the same whatever the make of car under consideration. Like most components of the present day, they are capable of giving the most reliable service over long periods; when adjustments are necessary, however, it is important that the correct procedure should be followed in order to get the best results.

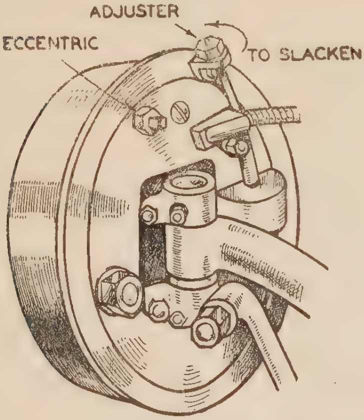


Fig. 15.—The adjusting points of Bendix brakes.

The owner of a car fitted with Bendix brakes will more readily understand why adjustments should be made in the way we will describe, if we first explain briefly the operation of the brakes.

In each brake-drum there are two shoes, faced with friction material.

When the brake pedal is depressed the brake-operating cable moves the upper shoe, which is known as the primary shoe, until it touches the drum. Since the drum is rotating it tends to move the brake-shoe with it, and in fact does so to a small extent. This movement causes the other shoe, the secondary shoe, to touch the drum also, and the continued motion of the drum drags both shoes round. The shoes cannot move more than a small amount, and their resistance to the drag of the brake-drum causes them to force themselves apart, and hence into increasing contact with the drum. It will be seen that both shoes must be kept in adjustment, in order that they both operate to an equal extent, and so wear down equally, giving smooth, progressive braking to the end of their life.

Equalizing the Adjustment.—To obtain this equal adjustment of the shoes, it is important that the following sequence of operations be exactly carried out.

First jack-up all four wheels of the car. This can be done with the one jack supplied with the car if suitable wood blocks or a number of bricks are available to act as supports for three of the wheels. Next raise the floorboards of the driving compartment and detach the brake cables from the cross-shaft. See that the cross-shaft works freely, and lubricate its bearings if necessary. It is advisable to tie a piece of string about twelve inches long to each cable, and to the cross-shaft lever, from which it was detached, to make quite certain that no mistakes will be made when re-connecting them. Make sure that each cable works freely in its conduit, and grease it if necessary.

Now proceed to the front of the car. Slack off the main adjustment fully by the ¼ inch nut on 1933 cars, or the hand nut on 1934 models. This adjusting nut is clearly indicated in Fig. 15.

The adjuster should be turned in an anti-clockwise direction on the left-hand brake-drums, looking from the front of the car, and clockwise on the right-hand side when slacking off. Then, with a $\frac{5}{16}$ inch spanner unscrew the eccentric locking-nut until the small square in its centre can be turned. This nut is also shown in Fig. 15. Turn the square *in the direction of forward rotation of the wheel* until the shoe just touches the drum, then turn it in the opposite direction until the shoe just clears the drum. Spin the wheel through several revolutions, to make sure that the shoe is not touching the drum, but the clearance must be the least possible. Now tighten the eccentric locking-nut, taking care that the square does not move. It is essential that the eccentric is turned in the right direction, as if it is wrongly adjusted the brake will lock hard on if applied while the car is moving backwards.

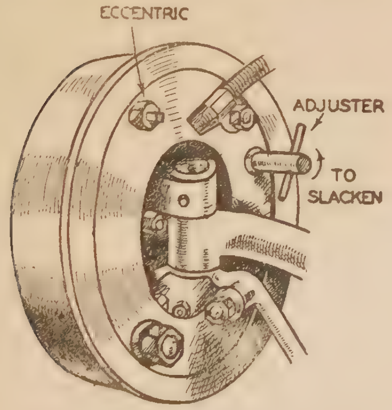


Fig. 16.—A later pattern of brake.

The next operation is to turn the main adjuster in the reverse direction, of course, from the way in which it was slackened, until the shoes are fully expanded in the drum, and the wheel cannot be turned by hand.

Each Drum in Turn.—This sequence of operations must be carried out on each brake drum in turn. When all have correctly set connect up the cables to the cross-shaft. Here, again, care must be exercised. See the hand-brake is in the "full off" position, and that the cross-shaft is right back against the stops. Pull each cable tight by hand and the pin should then just slide through the holes in the lever and the yoke on the cable. If the cable is too long, owing to wear, or too short, which sometimes happens, its length must be adjusted by turning the yoke so that it is screwed on or off the cable as required.

When all four cables are connected, return to the brake drums. Slack off the main adjuster, until the shoes are just free of the drum, which should revolve freely without any binding. When all the drums are done lower the car on to its four wheels and go for a short run to test it. It should be possible to apply the brakes hard at any speed without the car pulling to one side or the other. If this does occur,

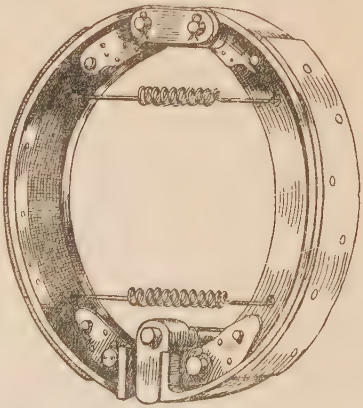


Fig. 17.—The brake shoes and closing springs, with coupling link and expander cam.

however, it can be corrected by slacking off the adjuster on the left-hand front brake, viewed from the driving seat, if the car pulls to the left, and on the right-hand brake if it pulls to the right. Do not turn these adjusters too far at a time. Turn them until they " click " once, and then test the brakes again. The rear brakes need not be altered unless adjustment of the front brakes has no effect. This is most unlikely.

Good for 5,000 *Miles.*—If this series of operations is correctly carried out, it will result in the brakes coming on simultaneously in all four wheels. No further adjusment should be necessary until at least 5,000 miles have been covered, when it will be found that the brake-pedal has to be depressed further before the brakes operate. When this happens, the whole series of adjustments described here should be carried out. This will ensure even wear of both shoes in each drum and hence smooth and progressive braking. Money will be saved, moreover, by eliminating the need for relining, except after a very considerable mileage, because as both shoes in each drum are in full operation, they will obviously last longer than if so adjusted that one does more work than the other.

BENDIX GEAR.—Name given to an automatic device which severs the connection between the electric starter and the engine-shaft immediately after the engine has been started.

BENZINE.—Chemical formula: C_6H_6. A light, colourless, refractive liquid, having a characteristic odour. Boiling point 80·5°C. It forms the main constituent of commercial benzole.

BENZINE.—A name, now becoming obsolete, given to one of the heavier petroleum distillates which, when, at one time, it began to be substituted for benzene, was given a name similar to the latter coal-tar product.

It should, therefore, not be confused with Benz*e*ne, to which it has no likeness in composition.

BENZOLE.—A well-known motor fuel derived from the distillation of coal-tar. It contains benzene, toluene and other hydrocarbon liquids in varying proportions.

BENZOLINE.—A name for the petroleum distillate, Benzine.

BERYLLIUM.—A light silvery metal, similar to aluminium and magnesium in appearance and properties. At one time very scarce, it is now becoming more plentiful and its alloys have been suggested as suitable for the construction of light pistons, valve guides and other parts. Contact-breaker points of beryllium alloy have been used recently on some American cars.

BEVEL DRIVE.—The rear-wheel drive for the car embodying the principle of the bevel-gear, two ordinary bevel wheels cut with straight or specially-shaped teeth being employed.

BEVEL WHEELS. — Toothed wheels having their faces set at an angle, usually at a right-angle. Used to transmit power from one plane to another.

The back axle assembly of a car contains a well-known application of the principle of bevel wheels.

BIG END.—Name given to the lower portion of the connecting-rod at its point of attachment to the crankpin.

BIG END BEARINGS.—If there is a considerable amount of backlash in the big end bearings they should be re-metalled, an operation which the amateur cannot undertake. It is possible for him to obtain bearings already re-metalled which only require to be scraped in, but before going to this expense, the crank pins should be callipered to determine whether they are oval or not. It is a waste of time to fit new bearings to a badly-worn crankshaft. The latter should be re-ground. This usually costs about 5*s*. per bearing, thus a four-cylinder engine with a two-bearing crankshaft would cost 30*s*.

Scraping Bearings.—The process of scraping a bearing is a slow one, demanding considerable patience and care. It is necessary to state here, by the way, that in certain engines the white metal is run direct on to the connecting-rod, no loose bearing being provided for that part. In such a case the manufacturers usually supply the complete connecting-rod and big end ready for scraping-in, and pass a credit for the old rod returned. To scrape-in a bearing, remove the cap of the big end and smear a little black lead mixed with thin oil into the crank pin. Red lead mixed with oil may also be used. Now secure the connecting-rod to the pin and give the shaft a turn or two and dismantle it again. With a half-round scraper, scrape away the metal where marked by the paint and repeat the process until the two halves of the bearing meet. Deal with one half at a time. At first it will be noticed the bearing will bind on the edges only. Repeat the operation with the second half of the bearing. Now bolt the rod and big end cap on to the pin. Rotate the crankshaft and then take the bearing apart and examine the markings. The metal should be scraped away until the marking is evenly distributed all over the bearings. Some big end bearings have shims fitted and these, of course, should be fitted during the scraping operation. When all the big ends have been dealt with in this way the oil-ways must be cut. The rods are removed and the oil-holes drilled where necessary. The type of oil-ways employed in the bearing will have been noted from the old one. The grooves are of semi-circular section, and most manufacturers supply them already cut. If they are not already cut, a round-nose chisel should be used or a round file bent to convenient shape. Having filed in the groove, give side clearance to the bearing as in the originals (Fig. 18). (See also *Crankshaft Bearings.*)

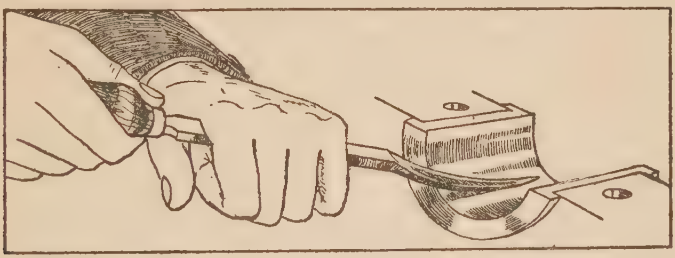


Fig. 18.—Using a Scraper on a Bearing.

BINDING.—The sticking together of parts or of surfaces.

The term is usually employed to denote the sticking of a piston in a cylinder owing to the influence of congealed and semi-burnt oil ; also to the condition of a wheel brake which, having been applied, refuses, for one reason or another, to " come off."

BINDING-POST.—A terminal on a Coil, Battery or other electrical device.

BLACKLEAD.—A coarse variety of graphite which is a form of the element, carbon. It has a scaly and flaky structure, a greasy feel and is employed as a lubricant. It also forms the basis of " Cylinder Blacks " for painting on the fins of air-cooled cylinders.

Synonyms : *Graphite, Plumbago.*

BLACK WAX.—An insulating composition used for filling up recesses around accumulator and battery terminals, etc. Composed chiefly of hard wax, resin and asphaltum.

BLEEDER SCREW.—A small screw plug fixed in the brake drums of cars fitted with hydraulic braking systems. After the removal of the screw, the brake fluid can be drained or " bled " away.

See *Brake Adjustment* and *Hydraulic Brakes.*

" **BLEEDING.**"—The operation of draining away the whole or part of the fluid of a hydraulic brake system in order to remove contained air.

BLOW-BACK.—Also known as " Popping." A minor explosion in the carburettor due to some of the still-burning exhaust gases escaping through the inlet-valve of the cylinder and igniting the ingoing mixture. It is usually brought about by faulty valve timing and, also, by an over-weak or an over-rich mixture.

BLOWER.—See *Supercharger.*

BLOWHOLE.—A fault in the cylinder wall, rare nowadays, due to the formation of an air-bubble during the casting of the metal. The presence of this air bubble may not have been revealed during the machining of the cylinder. Afterwards, however, under the normal influence of piston wear, the paper-thin cylinder wall covering the area of the air-bubble breaks down, revealing the blowhole as an irregular depression in the cylinder wall.

" **BLOWN.**"—Term referring to the condition of a fuse wire having melted owing to the passage of too heavy a current through it.

BLUE VITRIOL.—Chemical formula : $CuSO_4$. A popular name for Copper Sulphate. It forms well-known bright blue crystals and its solutions are employed sometimes for depositing a layer of copper on metal surfaces, facings, joints, etc.

Copper sulphate is also used in the copper-plating of metals electrolytically.

BOBBIN.—An old name for the induction coil of a car.

BODY.—The coachwork, seating and upholstery generally of the car as distinct from its under-frame or chassis.

A wide variety of materials and processes are now used for body construction. Whereas formerly the basis of the body was a forged framework known as the body iron, few cars nowadays have this solid backbone. Welded-steel bodies, pressed-steel bodies, papier-maché bodies, and fabric-covered framework bodies are the order of the day, but the tendency is for the coach-built body to return. See also *Body Styles* and *Cleaning the Body Work.*

Cleaning the Body Work.—Fortunately, nearly every car to-day is either fabric-covered or finished in cellulose. Nickel plating has given place to chromium plating and the great care necessary a few years ago to preserve the old varnish finish and to keep the plating clean no longer exists. Cellulose keeps its finish longer and improves with use. Chromium plating merely needs to be cleaned with a damp rag. In fact, metal polishes must not be used on it. There are many cheap spraying outfits specially designed for cellulose paint, which the owner-driver will find useful for touching-up purposes. There are, too, many excellent cellulose cleaning compounds on the market which preserve the new appearance. Before applying such compounds, the body should be hosed down with cold water, sponged, and leathered off and allowed to dry. Use the sponge and leather in one direction only, not in a circular manner. Do not allow mud and dirt to accumulate on the body work; wash it down fairly frequently. It is far better to remove mud at the end of the day's journey before it had been allowed to dry. (*See* Figs. 19, 20 and 22).

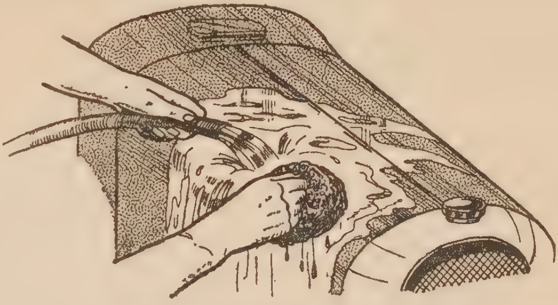


Fig. 19.—The hose-and-sponge method of removing caked dirt.

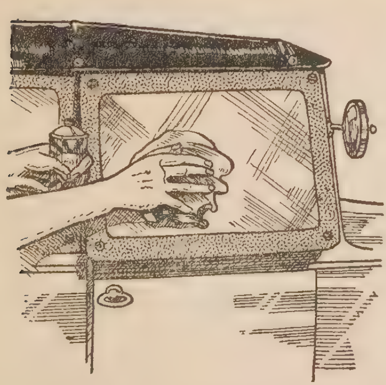


Fig. 20.—The best thing to clean celluloid and glass is metal polish.

Touching up with Cellulose.—Small scratches are bound to appear on the finish sooner or later, and pieces of the paint may become knocked off. Such places should be touched up with cellulose, confining the touching up absolutely to the affected parts. The bare metal is given successive coats until slightly proud of the surrounding paint. It is then rubbed down flush and polished. By this method the touching will be imperceptible.

Cleaning Celluloid.—Celluloid side-curtains should be cleaned with a rag moistened with ordinary metal polish. Metal polish also is useful for cleaning glass. When washing a car down remove the wheels and clean the caked mud from under the wing, otherwise the metal will rust through. Small cracks in wings may be welded locally for a few pence.

Noises.—Nothing can be more irritating to the owner-driver than noise. Noise usually means wear, mal-adjustment, or looseness of joints, and it is an illusive thing to trace. If the noise appears to emanate from the engine, the affected part can usually be traced by gauging its period. If it appears to be of the same frequency as the engine speed, the noise can be traced either to a fan-belt, worn fan-shafts, or some other part. Loose wings often give rise to a rattle. Slack springs, badly-adjusted shock absorbers, loose window glasses, slack door locks, loose nuts behind the dashboard fitments, weak bonnet clamping screws, loose lamp attachment, loose lamp glasses pedals fouling the slots in the foot-board, loose ventilators, badly fitting bonnets, broken bonnet tape, slack dynamotor fan, badly-fitting sliding seat rails, broken spokes, loose wheel bearings, slack control joints, loose body joints, badly arranged tool box—such are the usual causes of noise. Noises and squeaks should not be allowed to persist, for the longer they go on, the greater is the wear. Unwanted noise means movement of some part, and movement must mean wear. Reference should be made to Figs. 133 to 141 for suggestions as to possible sources of noise.

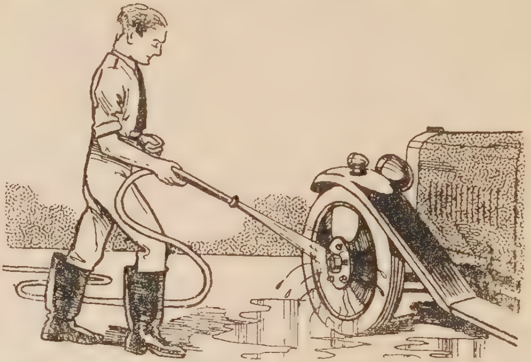


FIG. 22.—Disc Wheels are easily cleaned, but are inclined to magnify engine and chassis noises.

Fabric Bodies.—The great advantages of fabric bodies are that they cannot be scratched. They soon, however, look scrappy unless frequently cleaned. Cold water should be used for removing the mud, and a special fabric finish of the wax variety should be applied once a month. When the fabric reaches a condition that dust and dirt are permanently embedded in it, it should be scrubbed down with a small stiff brush, and paraffin.

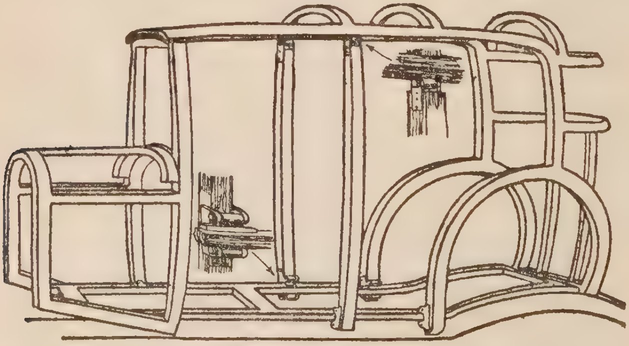


FIG. 21.—A Modern Body Frame, using Silentbloc bushes, and having rigid sections flexibly attached together.

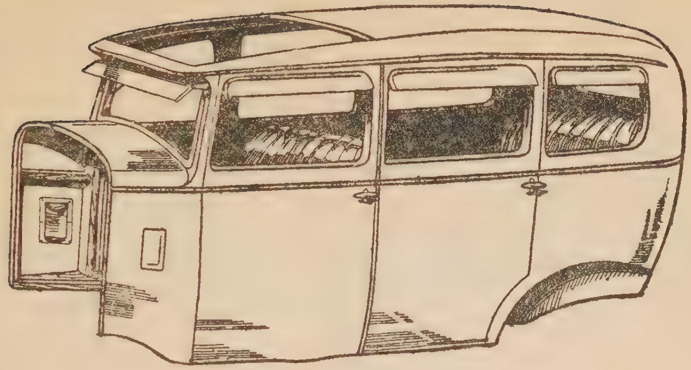


FIG. 23.—A Modern Six Eight Metal Saloon Body.

Thoroughly remove all traces of the paraffin, allow to dry, and then polish with wax.

Care of the Hood.—The waterproof hood should be kept raised when wet or damp. It should on no account be folded until it is thoroughly dry, otherwise it will deteriorate. Care should also be taken when folding to see that the material is not nipped by the hood slats. The hood may be cleaned by washing with soap and water.

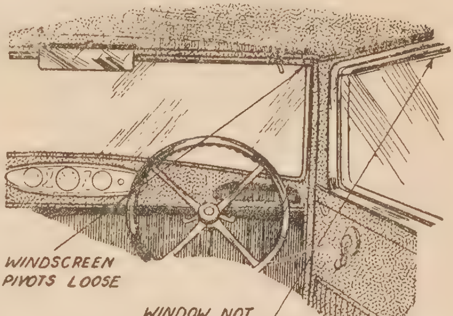


FIG. 24A.—Other sources of rattle are indicated in the above drawing.

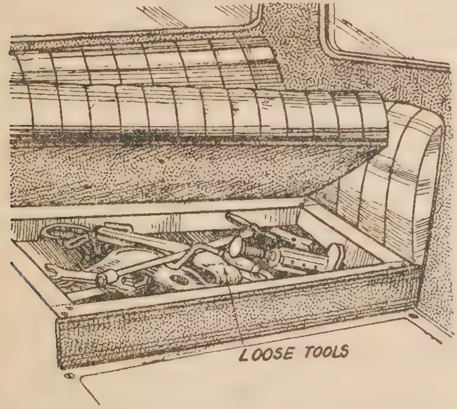


FIG. 24.—An obvious cause of rattles—loose tools.

Care of the Upholstery.—Cloth upholstery should be frequently brushed, and cleaned every six months with a strong solution of ammonia. Pneumatic upholstery should be kept inflated so that the material is forced out to its correct form. Leather upholstery should be washed with soap and water, and afterwards polished with leather reviver.

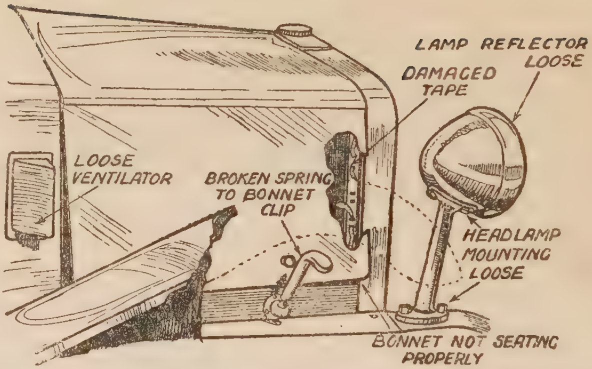

LAMP REFLECTOR LOOSE
DAMAGED TAPE
LOOSE VENTILATOR
BROKEN SPRING TO BONNET CLIP
HEADLAMP MOUNTING LOOSE
BONNET NOT SEATING PROPERLY

Fig. 25.—Some likely causes of Squeaks and Rattles in the front part of the car.

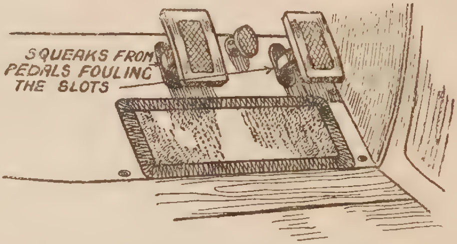

SQUEAKS FROM PEDALS FOULING THE SLOTS

Fig. 27.—The Foot Pedals should be adjusted to avoid fouling the slots.

The Running Boards. — Aluminium running boards soon lose their new appearance. This can be brought back by brushing them with caustic soda solution as recommended for flushing the radiator, taking care not to allow the solution to get on to the paintwork. Paraffin also will sometimes revive the finish if it has not gone too far.

The Radiator.—There is very little that an amateur can do in the way of repairing a radiator and it is recommended that when the leak is serious it should be put out either to the makers, the agent, or to one of the firms who specialise in radiator repairs. There are one or two compounds, however, which can be introduced into the water in the radiator and which will effectively stop up all small leaks.

If the gauge on a radiator indicates that the engine is overheating (a symptom by the way which would be accompanied by excessive loss of water by evaporation), the radiator itself should be flushed out by means of a strong caustic soda solution. To do this, first drain the radiator and replace the draining plug, or close the tap as the case may be. Then dissolve a pound of caustic soda in a pailful of hot water and carefully pour this into the radiator, taking care not to get on to the hands or to splash on to the paintwork. Start up the engine and allow

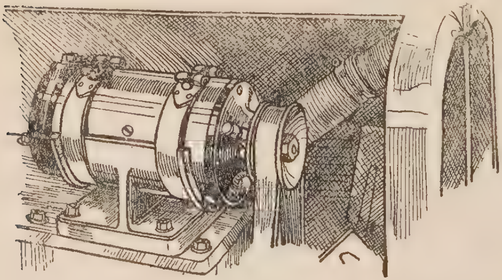


Fig. 26.—A Slack Dynamo or Fan Belt, or one of the wrong type, is often the cause of a subtle form of clatter.

BODY STYLES 1

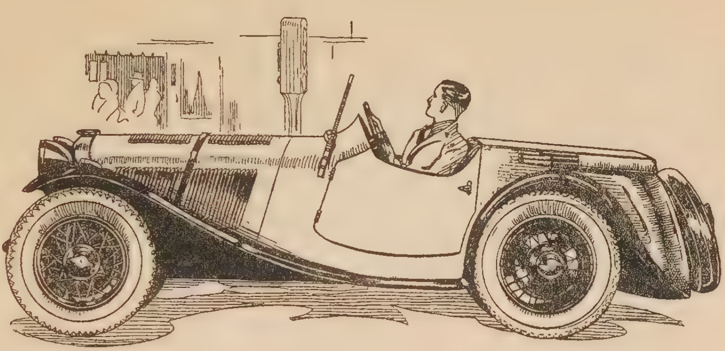


FIG. 28.—4-Seater Sports.

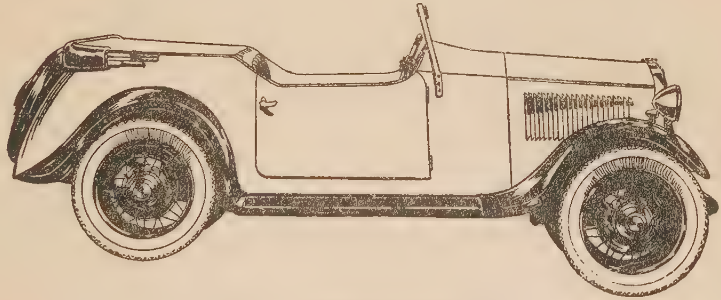


FIG. 29.—4-Seater Sports Tourer.

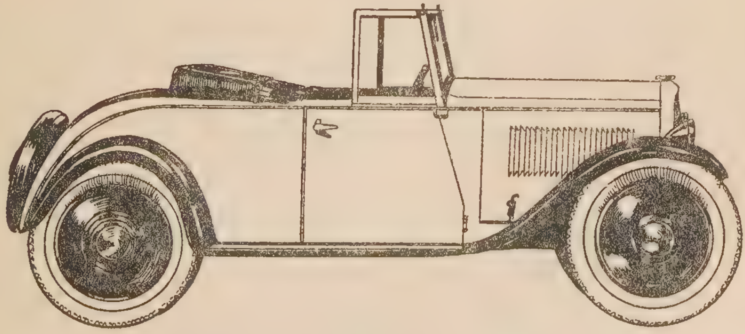


FIG. 30.—2-Seater Tourer of conventional design.

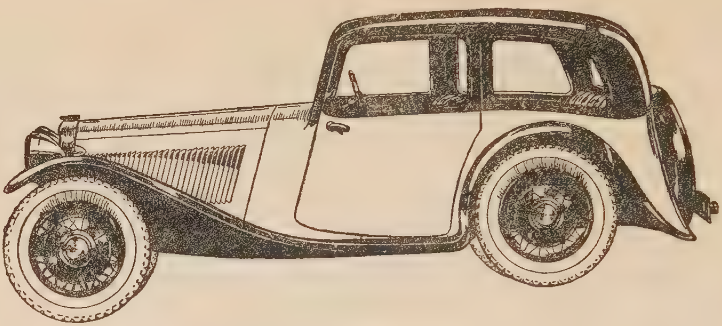


FIG. 31.—4-Seater Saloon.

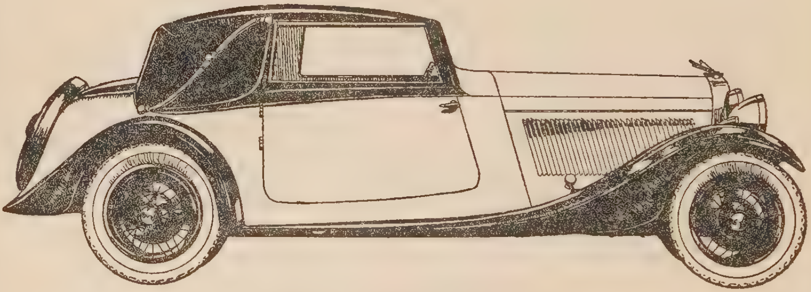


FIG. 32.—Close-coupled Coupé.

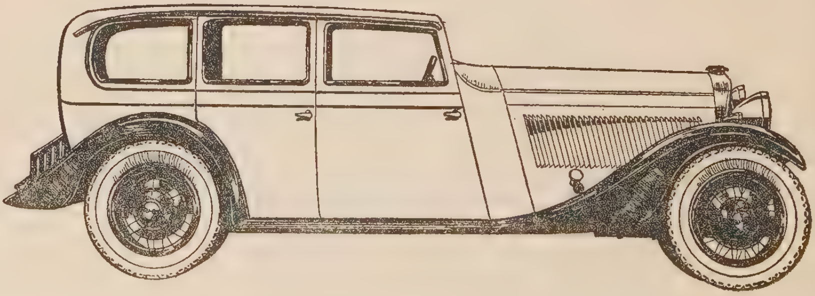


FIG. 33.—Enclosed Limousine.

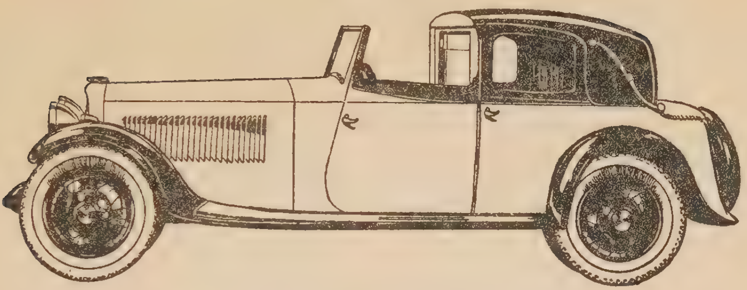


FIG. 34.—Coupé de Ville.

this to circulate for ten minutes or so. Next, drain the radiator again and thoroughly flush the radiator with a hose-pipe, allowing it to run for five minutes or so. You will be astonished at the amount of slush which the caustic solution will bring away with it. This treatment is usually sufficient to prevent overheating caused by an obstructed radiator. It is advisable to flush the radiator (not with caustic soda, of course), once a month. It is also advisable to see that the overflow pipe is clear.

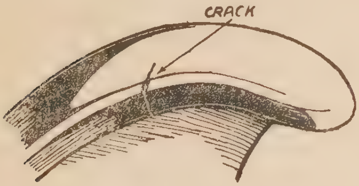


FIG. 35.—Cracks in the wings should be welded. It is quite cheap and makes a first-class repair.

BOILED OIL.—Linseed oil (obtained from the seeds of the Flax plant), which has been boiled until it thickens. Used often for smearing over the surfaces of packings which are required for the making of gas-tight joints.

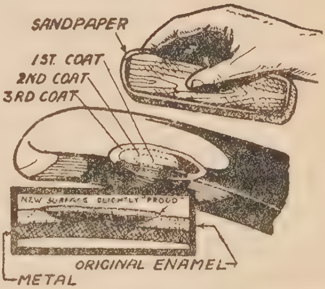


FIG. 36.—How to Re-enamel locally with Cellulose. The bare metal is given successive coats until slightly proud of the surrounding enamel, and then rubbed down flush and polished. The repair is then imperceptible.

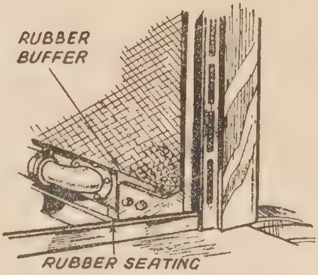


FIG. 37.—Persistent Radiator Leaks may be due to jolting, caused by Perished Rubber Seatings.

BOILING-POINTS.—In fuel technology the boiling-points of motor spirits are very important factors as they are carefully determined. The higher the boiling-point of a fuel, the more difficultly vapourised it is.

The boiling-point of an average sample of high-grade petrol is very much lower than that of commercial benzole.

BOLT.—A metal rod or shaft having a head at one end, the other end being screwed to receive a nut or to fit into a tapped hole. Used for joining up metal parts in firm contact. Engineering bolts are of many different types.

BOLT-VALVE-PLATE.—A metal plate which fits around the stem of the tyre air valve. When the latter is screwed up the bolt valve plate is drawn down between the beads of the outer cover, forcing them into position.

BORE.—Term usually referring to the diameter of the portion of a cylinder in which the piston works. Cylinder bores of internal-combustion engines are measured in millimetres. (*m.m.*).

BOTTOM DEAD CENTRE.—Name descriptive of the position of the piston when it reaches the lowest point in its travel within the cylinder and is about to begin its upward journey.

BOUNCING - PIN METHOD. — Name given to a method of determining the detonation values of fuels in which use is made of a vertical oscillating rod operating within a metal tube and making contact at the lower end with a strong steel diaphragm. The tube is screwed into the cylinder head of the experimental engine and the vertical rod, oscillating under the influence of the detonating fuel, is made, at its upper end, to control the volume of gas generated in an electrolytic cell, the quantity of gas produced being carefully measured and thus serving as an indication of the degree of detonation set up by the fuel.

BOX SPANNER.—A non-adjustable spanner which slips over a nut, gripping all its sides at the same time.

BRACE.—A rod, bar or girder stretching between two members and holding them tightly together, as, for instance, the cross-braces of a car frame.

BRAKE.—A frictional device for stopping or retarding the motion of a moving part. In car-construction, the brakes are made to act directly upon the road-wheels of the vehicle. (See also *Bendix Brakes*, *Brake Repair*, and *Hydraulic Brakes*.)

BRAKE-COMPENSATOR. — A compensating device which is fitted to some cars to equalise the control-pressure between the brakes of opposite wheels.

BRAKE-DRUM. — The outer metal casing attached to the road wheels of a car. It contains the entire brake assembly—brake shoes, cam and springs.

BRAKE FLUID.—A special liquid used in brake systems of the hydraulic type. It is non-freezing at ordinary low-temperatures, nor does it attack rubber or metal tubes.

BRAKE HORSE-POWER.—The horse-power available at the flywheel of an engine, so called on account of its usual method of measurement which consists of the application of a brake.

BRAKE-LINING.—Special friction-producing lining of fabric or other material which is attached to the brake-shoes and which makes contact with the inside of the brake-drum.

BRAKE REPAIR AND ADJUSTMENT.—There is little need to tell the reader of the importance of keeping the brakes at the correct adjustment. The application of the brakes, and the manner in which they pull up the car provide positive indication as to the adjustment required. Figs. 38 and 39 shows the chief parts of the usual type of internal expanding brake, whilst Figs. 40 and 41 indicate the working principles. The complete four-wheel system is shown by Fig. 42.

Chattering Brakes.—If when the brakes are applied the car comes to a shuddering standstill they should be attended to immediately. If a considerable distance is required in which to pull up, they may require adjusting or even re-lining. The common trouble with brakes is due to the toe-end of the leading shoe being picked up by the revolving drum. This trouble will give a chattery effect when the brakes are applied. The remedy is obviously to reduce the thickness of the end so that they make more gradual contact. If the trouble is not caused by the foregoing, it may be due to the slackness of the camshaft bearing or of the shoe-pivot pins. These troubles can only be corrected by fitting new parts, or by fitting stronger springs between the shoes. Sometimes oil on the brake drums will cause the trouble, worn or dented brake drums may also cause chatter, in which case they should be trued up by skimming in a lathe. Slack bolts or rivets in the back plate or brake drum is another cause. It is well to check over the spring anchorages to the axle, and make sure that the bolts are drawn up quite tight. Another cause of brake chatter is slackness in the wheel bearings. As these are of the roller or ball-bearing type the remedy here is obviously one of replacement.

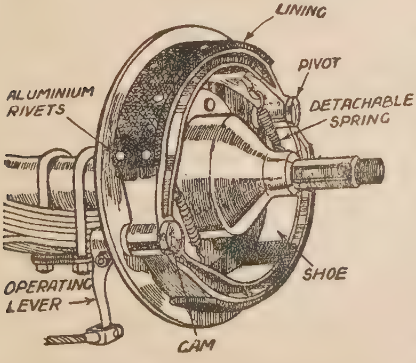


Fig. 38.—A Rear Brake with the Cover removed.

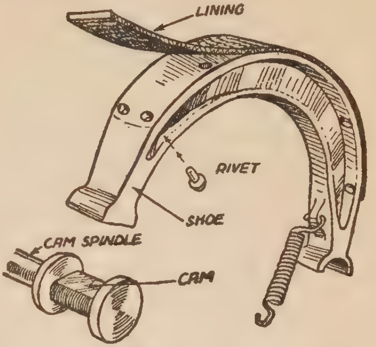


Fig. 39.—A Brake Shoe, showing how the lining is fixed.

Pivot Wear.—Brake shoes which persist in remaining in engagement with the drums, however much the adjustment is slackened off, are usually suffering from excessive wear at the pivot point. Oversize pins may be fitted in this case, or new shoes.

Uneven Brake Action.—When one brake exerts a greater force than the remainder, the operating mechanism should be given attention. Lack of lubrication may be restricting the proper action of the brake gear, or if compensating mechanisms are in use it may be due to faulty adjustment, in which case matters may be rectified by slackening off one adjustment and tightening the other. The remedies for a bent front wheel brake camshaft is to remove it by releasing the brake shoes by removing their take-off springs. It may then be straightened by hammering between two " V " blocks or by vice pressure.

Excessive Wear.—If an excessive amount of pedal movement is required to apply the brakes, in spite of the fact that the clearance between the shoes and drums have been correctly set, it is indicative of wear at the various joints. Attention to this in the matter of renewal should rectify matters.

Stiff Braking.—Stiffness in the brake mechanism is usually caused by lack of lubrication, and it is often necessary in trouble of this kind to pull off the drums, lubricate every part, and make certain that the action is even and adequate before reassembling. In some cases such stiffness may be due to a bent chassis. With cable-operated brakes the pulleys should be examined to see that they resolve freely and that the cable is not frayed. In certain designs which have two cross shafts connected by gearing, the teeth may be choked.

Poor Brake Action.—This is usually the result of worn linings, oil on the linings, or operating levers at the wrong angle. Sometimes also to faulty brake drums as already indicated. Re-lining the brakes will often effect a cure of wrong lever angle.

Brake Adjustments.—Presuming that all the component parts of the brake are working freely, especially the brake camshaft, brake adjustments may be carried out in the following order. The first essential is to make sure that the brakes are properly equalised, that is, that each brake does its correct share of breaking. The best way of doing this is to jack all four wheels clear of the ground, and to depress the pedals by jamming a piece of wood between the pedal and the driving seat. A depression of about 2 inches should be sufficient to apply the brake. Individual adjustment should now be screwed up until the wheels can just be forced round by hand, each offering exactly the same resistance to rotation. In the case of brakes compensated by the balance-lever method, it is also necessary to see that this lever is at right angles to the pull-rod when the brake is applied. With cable-operated brakes, twisting of the cable must be avoided. When the adjuster is in use the cable end should be firmly held against rotation, while the adjusting-nut is screwed up. A hexagon is usually provided for this purpose. Now release the brake pedal and test each wheel for freedom, and slacken the main adjustment if necessary, until all shoes are clear of the ground. A

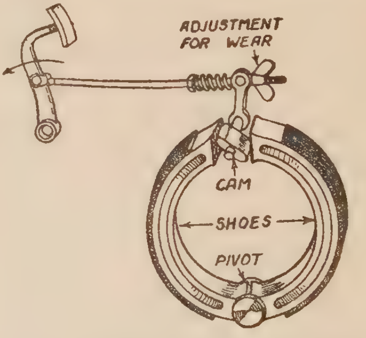


Fig. 40.—How an Internal Expanding Brake works. This example has been adjusted for wear so that the cam is already partly turned before depressing the pedal.

road test should be given as a final test. The car should be taken to a quiet road and the brakes applied hard with the car travelling at approximately 20 m.p.h. The skid marks will at once show if all brakes are applied evenly. After this test, lightly tap the drum with a spanner; if they ring clearly all is well, if the drum gives off a dull sound one of the shoes is rubbing. This test, of course, does not apply to drums which have been equipped with silencing bands.

Renewing Linings.—If the tests already outlined indicate that relining is necessary, first remove the drums. It is important to release the brake shoes by disconnecting the pull-rod at its junction to the camshaft lever. Then unfasten the screws or bolts securing the drum to a flange on the hub. If the drum does not come off easily, give it a few whacks round the outside with a block of wood, detaching the shoes. It is always advisable to mark the shoes before they are taken off to ensure that they are replaced in the same position. The removal of the shoes will be obvious upon inspection. Linings of the right length, width, and thickness, can be obtained from the makers, and in many cases these are already drilled and countersunk for the rivets. It is important that all brake linings should be of the same make. If correctly formed linings are not obtainable, a length of the right thickness and width should be obtained from the makers, which should be cut off to the correct length with a hacksaw. Do not make the lining too long, otherwise it will tend to cockle and give rise to brake chatter. The next thing is to bend it to the correct curvature, and this is facilitated by heating the lining to an even temperature in front of a fire or with a blow-lamp. When warm, the lining will be pliable.

Attaching the Lining.—Clamp each lining to its shoe by means of fretwork clamps, and drill through the shoe into the lining. Countersink the holes in the lining to receive the rivets to ensure that they will not come into contact with the drum. An ordinary countersink may be used for this purpose. Fasten a piece of mild steel of appropriate section into the vice for use as an anvil while the rivets are being hammered over. Inset a rivet through the lining and brake flange. Its head should be rested on top of the mild steel bar and its shank riveted over on the inside of the flange with a hammer. This will pull the head of the rivet down into the lining. The end rivets should be inserted first, then the clamps should be moved adjacent to the next rivet, proceeding as before. It is best to drill only the end holes first and to rivet these before drilling the other holes.

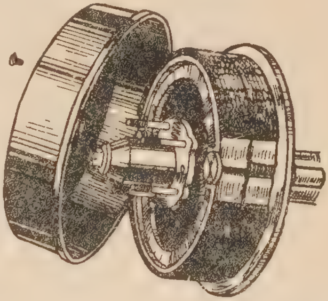


FIG. 41.—A Rear Brake with Drum removed, showing separate Shoes for Hand-brake.

Chamfering the Linings.—To ensure smoothness of action and to avoid brake chatter the ends of the linings should be chamfered off for approximately 1½ inches of their length at each end. This may be hacksawed off or removed with a file.

Replacement.—After replacing the shoes some little difficulty may be experienced in replacing the drum, owing to the thickness of the new linings. A little hammering down or trimming with a file will usually rectify matters. If the brake drums are badly worn they should be skimmed up in the lathe before replacement.

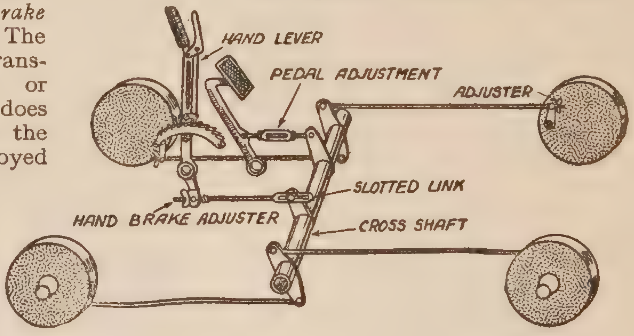


FIG. 42.—A Simple Layout for the Four-Wheel System. The slotted link prevents the hand lever moving when the foot pedal is used.

Transmission Brake Adjustment. — The adjustment of transmission brakes or parking brakes does not differ from the method employed except that the adjustment is usually provided in the pull-rod between the hand-brake lever and camshaft lever. Some transmission brakes, however, are of the external contracting type Such mechanism is usually provided with adjustment at one or both ends of the shaft, which should be tightened up until each of the shoes is just rubbing, when the brake has been pulled on to the third or fourth tooth on the quadrant. With cars equipped with a hand-brake operating on the transmission only, jacking of one rear wheel destroys all hand-brake action. Such jacking, therefore, if carried out on an incline necessitates chocking the wheels. Thoroughly lubricate all working joints at least once every 1,000 miles.

Vacuum Servo Brakes.—Vacuum servo brakes need but little attention in the way of lubrication, a charge of oil in the lubricator every 1,000 miles being all that is required. Thin engine oil should be used.

Hydraulic Brakes.—Hydraulic brakes naturally need no lubrication except very occasionally at the brake shoe pivot pin, since the system employs a fluid which is in itself a good lubricant. Hydraulic brake operation automatically ensures equality of brake application and requires no special maintenance in this direction. The only precaution with this system is to see that the fluid pipe lines are kept free from air and that the master cylinder on those systems which do not automatically replenish is kept filled with brake fluid. Hydraulic brakes have the great advantage that there are no coupling-rods or joints to give rise to rattle and noises. The principle is that all fluids are incompressible, and that when pressure is applied to a small area of the surface of a fluid enclosed in a vessel, that pressure is transmitted equally and without diminution to the rest of the liquid. In the well-known Lockheed system which is typical of hydraulic braking systems, the brake pedal is connected by a short lever to a piston in one end of a cylinder, which is completely submerged in a supply of fluid. The other end of the cylinder is equipped with two concentric valves opening in opposite directions. Pressure on the brake pedal applies pressure to the fluid and forces open the central or outlet valve, thus communicating pressure to the fluid in a series of pipe lines branching from the end of the cylinder, the other ends of the pipe lines are led to each wheel where they communicate with the centre of a cylinder, open at each end and provided with a pair of opposed pistons situated inside the brake. The pressure applied to the fluid, forces the piston and the brake shoes to which they are connected by short push rods, apart, thus applying the brake. When the brake pedal is released, pull-off springs force the wheel brake cylinder pistons into the off position returning the fluid to the pipe line. The brake pistons are equipped with rubber-cupped washers which expand against the cylinder-walls under pressure, and prevent leakage of the fluid. The hydraulic brake system is shown by Fig. 43.

Hydraulic Brake Upkeep.—No oil should be introduced into the hydraulic brake cylinders as this would perish the rubber. Special brake fluid only should be used, or in cases of emergency a mixture consisting of 50 per cent methylated spirit and 50 per cent castor oil. Attention to the level in the master cylinder is needed about once every 1,000 miles. If air is allowed to leak into the system when the brake pedal is applied there will be a soft cushioning effect instead of a solid resistance. The system must therefore be bled. To do this, first of all obtain a supply of the recommended fluid and see that the supply tank is well filled. At the top of the wheel cylinder will be found a hexagon-headed screw with a plug screwed into its centre; this is the bleeding valve. Remove the plug, and screw in its place the special nipple and length of rubber tube supplied by the makers. Thread the rubber tube over the nipple, and let the other end of the rubber tube hang into a glass jar in which is a quantity of the brake fluid. Unscrew the bleeding valve about three-quarters of a turn, then depress the brake pedal slowly by hand, permitting it to return to the off position. This will force fluid into the jar, and the presence of air

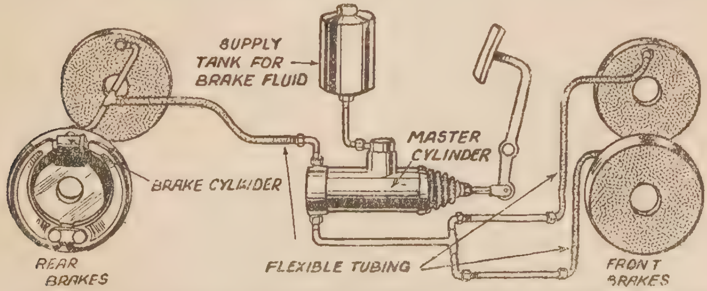
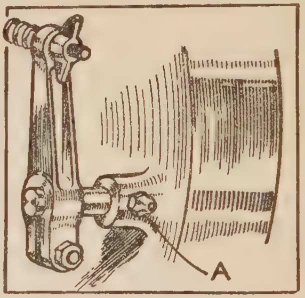


Fig. 43.—In the Hydraulic System fluid is compressed in a Master Cylinder and conveyed by tubing to a small cylinder and piston in each drum. These operate the shoes.

will be observed when bubbles issue from the mouth of the rubber tube. Continue to pump until bubbles cease, frequently replenishing the fluid in the brake cylinder so that the level does not drop below that of the master valve. Should this happen, the whole system will need to be bled again. When the fluid runs clear, and free from bubbles, then the valves should immediately be shut off without removing the end of the rubber tube from the fluid in the glass jar.

Brake Testing and Repair.—Nearly every driver will spend hours cleaning sparking-plugs and doing other similar jobs if he finds that the car is not pulling quite so well as it might, but very few give similar attention to the brakes, which are, surely, of far greater importance. Probably one reason why brakes are more or less ignored is that their efficiency (or lack of it) is not always so readily noticeable, unless measurements are taken of stopping distances at various road speeds. It is a very wise plan to try the brakes as soon as possible after leaving the garage, every time the car is taken out. This only involves the use of the hand- and foot-brakes for half a minute or so, just to make sure that they are really effective. This might sound an unnecessary precaution to many, but there are a number of cars (and modern ones at that) whose brakes are practically useless if linings have become slightly wet due to dampness, travelling over wet roads or to the car having been washed. Additionally, it is not an unknown thing for the brake-levers to " bind " or seize.



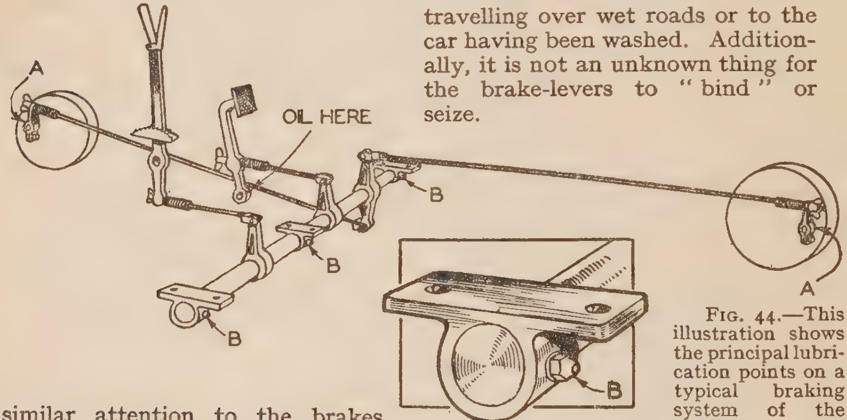


FIG. 44.—This illustration shows the principal lubrication points on a typical braking system of the cable- or rod-operated type.

There is no reason whatever why any brakes, if they are properly looked after, should bind. It is only a matter of lubricating them every few thousand miles, and there are usually no more than six or seven points which require attention with the grease-gun or oil-can. The exact points are always referred to in the maker's instruction book, but the sketch given on page 32 (Fig. 44), will make the matter clear to any readers who are running an old car, for which they have no lubrication instructions. It will be seen that the principal points to watch are the ends of the brake cross-shaft and the toggle levers, one of which is fitted to each brake-drum. The drawing given is on the assumption that four-wheel brakes are fitted, and that both hand-lever and pedal can be used to operate them. Some older cars have two sets of brakes, one operated by means of the hand lever and the other by the pedal. In such cases the hand lever is often used to control the brakes on the front wheels, the pedal operating on the back ones only. In other cases there are two sets of shoes on the back wheels, one of these being connected to the pedal and the other to the lever. The principal is, however, always the same, and it will be found that there is a lubricating point for every set of shoes, as well as for the cross-shaft and the hand lever.

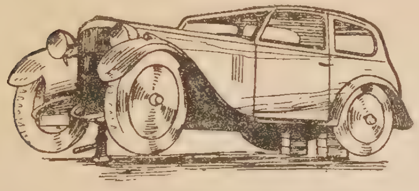


FIG. 45.—The brakes can easily be adjusted if all road-wheels are lifted off the ground, shown above.

Although regular lubrication is essential it must be clearly borne in mind that an excessive amount of lubricant will probably lead to trouble, since it might find its way on to the linings. It will, therefore, be found that a single "shot" with the grease-gun, or a couple of drops of oil (according to the type of lubricators fitted) at each point once every 500 miles or so is just about correct.

The Effects of Over-lubrication.—If a bearing does seize due to incorrect lubrication the correct procedure is to apply a few drops of one of the many varieties of penetrating oil, or of paraffin, allow this to remain for a short time, after which the bearing should be entirely freed. Wipe off the oil and lubricate in the usual manner. When lubrication has been overdone so that the brake-linings have become covered with grease or oil, the only thing is to remove the shoes and thoroughly wash them in petrol, rubbing them over with a wire scratch brush. In doing this, however, make quite sure that the excess lubricant has, in fact, come from the brake-shaft lubricator and not from the back-axle or wheel-hub. If it has come from either of the latter sources, it

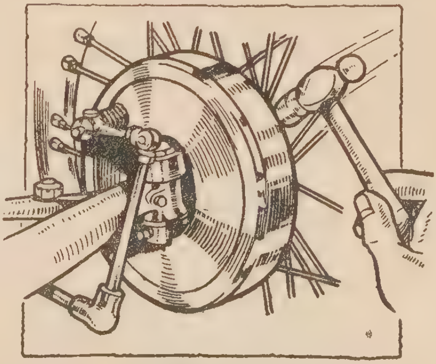


FIG. 46.—By tapping each brake drum in turn with a hammer the brakes can quickly be tested, as explained in the text.

will be evident that one of the packing washers has perished or been damaged, and this must be attended to before the brakes are re-assembled.

Brake Adjustments.—And now to consider the question of adjusting the brakes. When they are on all four wheels, it is generally desirable to ensure that they all come on together, although there is apparently some divergence of opinion on this point; some engineers hold that the front ones should come on slightly before the others, whilst others say that those on the rear wheels should be applied first. In favour of the first argument it is stated that, when the brakes are first applied, the weight of the car is thrown forward on to the front wheels, so that if the rear wheels were braked more heavily there would be a danger of skidding. It is not proposed to pursue that argument here, but instead to describe the method of adjustment whereby the brakes are applied almost simultaneously to all wheels.

It is usually recommended that all the road-wheels should first be jacked-up off the ground, this being done by first jacking-up the rear wheels separately and supporting the axle with bricks, and then jacking-up both front wheels by placing the jack under the centre of the front axle (*see* Fig. 45). This method is probably the best in many cases, but the following idea is simpler and quicker. Tap the brake-drums in turn with a hammer, if the shoes are not touching a clear " ringing " note is heard, but if they are touching a dull sound results (*see* Fig. 46). Thus, if all brakes are set until the shoes are just touching the drums it is only necessary to slack-off the main adjusting nut by about half a turn.

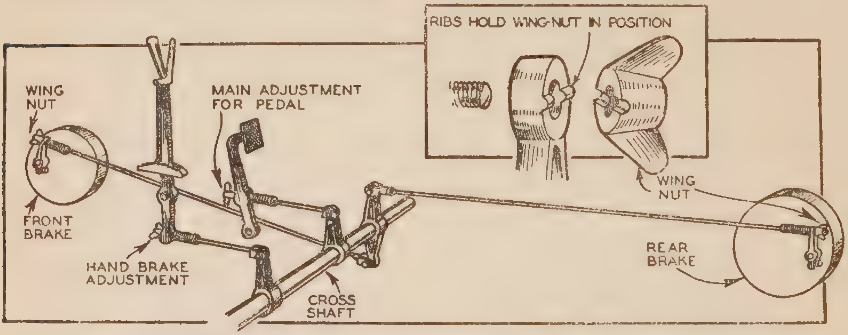


FIG. 47.—The various points of adjustment on a four-wheel braking system in which the hand and foot controls operate on the same shoes.

The actual method of making the adjustments calls for little explanation, although it does vary to a certain extent with different cars. Generally the arrangement is something like that shown in Fig. 47, where there is a large wing-nut (usually found under the floorboards or just under the bonnet) for the main adjustment on all four wheels, and separate wing or hexagon nuts near the ends of every brake-rod. In the case of cable-operated brakes, however, the front cables are generally adjusted by means of a nut at that end of the cable which is joined to the cross-shaft, as shown in Fig. 48.

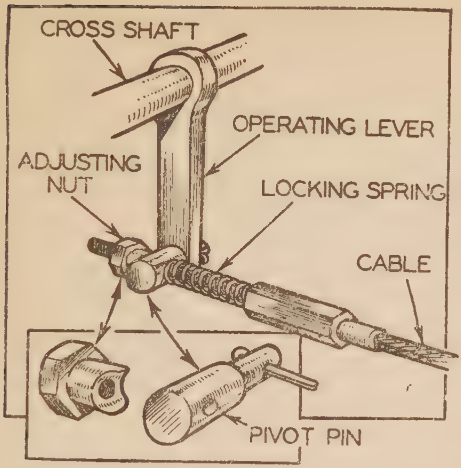


FIG. 48.—This illustration shows the manner in which the front-wheel brakes of the cable-operated type are usually adjusted.

A Point to Watch.—A special point must be mentioned in respect of most types of front-wheel brakes, because the pressure of the shoes on the drums is largely dependent upon the steering-lock. For example, when the steering is locked well over, the brake on the "inside" wheel generally comes "on" long before that on the "outer" wheel, and slightly before those on the rear wheels. In making the adjustments, therefore, it is best to lock over the front wheels, first in one direction and then in the other, and so to arrange matters that the brake on the "inside" wheel comes on at the same time as do the rear-wheel brakes. This will prevent one front wheel brake from being applied unnecessarily when cornering and manœuvring the car.

The adjustments of the brakes by means of the nuts provided on the operating-rods will only be effective so long as the linings are in good condition, but it is quite possible to "take up" the brakes too much, so that "binding" occurs. This point will more readily be understood by making reference to Fig. 49 which shows the shoes of a typical brake after the drum has been removed. It will be noticed that the operating cam has been rotated to its maximum position in which the return springs are useless. If it were possible for the cam to assume such a position when the drum was in place, the brake would simply stick in the "full on" position, instead of coming "off" when the pedal or lever were released. Whenever it is found that the brakes have to be taken up nearly as far as possible, it is at that time, wise to note the position of the lever or pedal when the brakes are full on, and then to release it and remove the drums. After that the pedal or lever can be moved to its previous position, and the amount of rotation of the cam observed; if it makes an angle of more than about 45 degrees with the end faces of the shoes, something should

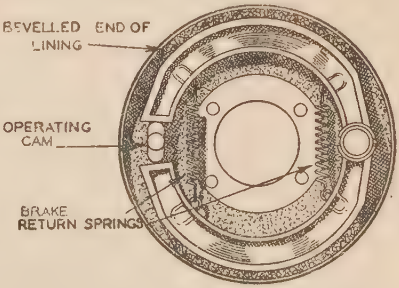


FIG. 49.—The above diagram shows how the brakes can lock if they are taken up so far that the operating cam assumes the position indicated when the pedal is fully depressed.

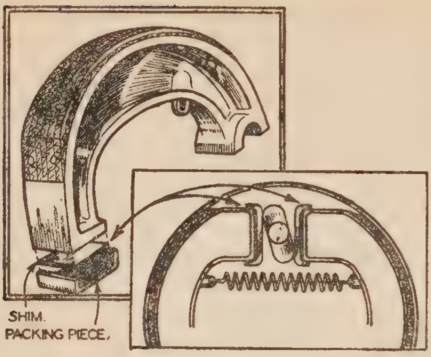


FIG. 50.—If the linings are not too badly worn the difficulty illustrated in Fig. 49 can be overcome by fitting packing pieces and shims to the ends of the brake shoes.

be done about it. The obvious thing would be to renew the linings, but unless they are badly worn or scored they may be used for a much longer period by fitting packing-pieces to the ends of the shoes. The packings can be made from stout tinplate or mild-steel sheet, as shown in Fig. 50. They are simply made to fit over the ends of the shoes, but additional shims in the form of small rectangular pieces of metal, can be made to fit between the packings and the shoes; these also are shown in Fig. 50.

Fitting Packing Pieces.—It will probably be necessary to remove the shoes in order to fit the packings and this can easily be done if the return springs are first disconnected. The springs are usually very strong and can most easily be released by looping a piece of strong cord and slipping this in the end loop as shown in Fig. 51. Remove first the spring on the same side as the cam, after which the other will come loose by "bending" the shoes away from the back plate.

Curing "Judder."—There is one other point which should be considered in regard to the brakes; that is "judder," or vibration which is experienced when the brakes are applied, especially at low speeds. This may be caused by two principal things, one of which is roughness of the linings and the other is looseness in the spring or axle mountings. Only the first will be considered here since it applies to the brakes. When "judder" is noticed the brake-drums should be removed and the linings examined for scores, due to roughness inside the drum, and for "proud" rivets. When scores have been produced by the drums it is well to have the latter "skimmed" out on the lathe, besides which it is often wise to replace the linings also. Projecting rivet-heads can best be dealt with by removing the shoes and countersinking the rivet heads in the manner illustrated in Fig. 50. Another cause of "judder" is the omission of chamfering at the ends of the linings.

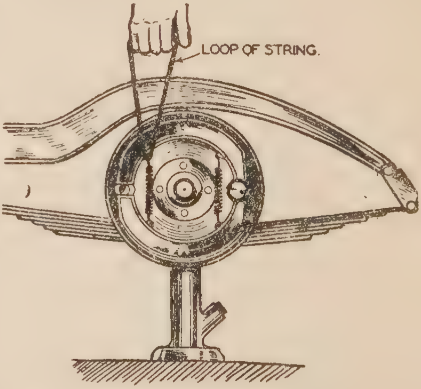


FIG. 51.—The simplest way to remove the brake-shoe springs is by means of a loop of string or wire, as shown above.

BRAKE-ROD.—Steel rod which connects the brake-lever and, also, the brake-pedal to the brake mechanism of the car.

BRAKE SHOES.—Name given to the curved steel members of an internal-expanding brake which, being faced with asbestos-composition, are, by a special mechanism, caused to expand against the inner rim of the brake drum, thereby setting up braking friction.

BRAKE SPRINGS.—Helical tension-springs which tend to pull the brake shoes together so that normally the latter do not make contact with the interior of the brake-drum.

BRASS.—An alloy containing varying proportions of copper and zinc. Common brass used for fittings, etc., contains two parts of copper and one part of zinc.

BRAZING.—The soldering together of two metallic surfaces by means of a brass-like alloy containing zinc and copper.

BREAK.—Expression used to denote the means of rapidly interrupting the flow of an electric current. The trembler-break on the induction-coil of some cars is an example of this term.

" BRIGHT " FILAMENT.—The filament in a dual-filament headlamp electric bulb which glows brightly and gives the normal illumination.

BRINELL TEST.—An engineering test for the hardness of materials used in automobile construction.

It consists in placing a 10 mm. steel ball on the surface of the material to be tested for hardness and in then applying to the ball a standard pressure of 3,000 kilograms for a standard period of time (usually a quarter of a minute). The steel ball is pressed into the surface of the material, and, after the test, the diameter of the resulting depression in the material is measured by means of a low-power microscope. Reference to a table of " Brinell " degree of hardness is then made, the degree of hardness of the material being read off against the diameter of the depression thus made in its surface.

BRITISH THERMAL UNIT. — The unit of heat standardised in this country. Abbreviation : B.T.U.

One B.T.U. is the amount of heat required to raise the temperature of 1 pound of distilled water at its temperature of maximum density (39·1° Fahr.) one degree Fahrenheit.

BRONZE.—An alloy containing varying proportions of copper, zinc and tin, used sometimes in the manufacture of car accessories and fittings. Not to be confused with *phosphor-bronze.*

BRONZING.—A method of colouring brass and other non-ferrous metals by the use of certain chemicals. Sometimes employed for the finishing of car instruments and various accessories.

BRUNSWICK BLACK.—A cheap black varnish made from asphaltum. Drying quickly, it is much used in garages and workshops for protecting metal surfaces, underframes, wings, etc., particularly when they have been rusted or damaged.

BRUSH.—Electrical term usually given to a block of carbon, suitably supported in a holder, which provides for the collection of current from the revolving metal ring in a magneto or from the commutator of a dynamo.

B.S.A. THREADS. — British Standard Automobile threads. A range of standardised screw threads which extend over fourteen sizes from ¼ in. to 1 in. They are very similar to the B.S.F. threads, varying from the latter in dimensions only in the ¼ in. and $\frac{9}{32}$ in. sizes.

B.S.A. hexagon nuts are smaller than those of the B.S.F. standard.

B.S.F. THREADS.—British Standard Fine Threads. A range of standardised threads very similar to the B.S.A. threads, but having larger bolt heads and nuts.

The British Standard Fine differs from the Whitworth standard in having more threads to the inch. It is a development of the original Whitworth standard thread.

B.S.P. THREADS.—British Standard Pipe Threads. A range of standardised threads, examples of which are occasionally to be met with on old cars. These screw-threads differ from Whitworth threads not in cross-section but in their diameter and the number of threads per inch. As the name suggests, B.S.P. threads are intended for pipe-union connections and similar work.

B.S.W. THREADS.—British Standard Whitworth Threads. See *Whitworth Threads.*

BUCKLE.—The bending or distortion of a metal part by straining or by external pressure. A car wheel, for instance, may be buckled by collision with some object.

BUCKLING. — Term commonly used to denote the deformation of the lead plates of a car battery, due, usually, to prolonged faulty charging and discharging.

BULB.—Term usually referring to the various electric filament bulbs for car-lighting purposes. These are of many types.

BULB HORN.—The simplest and oldest form of motor horn, consisting of a rubber bulb attached to an air-conduit or trumpet, a small reed being interposed between the two parts. When the bulb is squeezed a blast of air is forced through the reed thus causing it to vibrate and to emit a note which is reinforced by the tonal characteristics of the trumpet or sound-conduit.

Bulb horns have been displaced by mechanically and electrically-operated devices, but they are still frequently carried on cars, if only for use as a stand-by.

BUMPERS: BUMPER BARS.—Name given to metal bars stretched in front of the car for the purpose of reducing the force of any accidental impact.

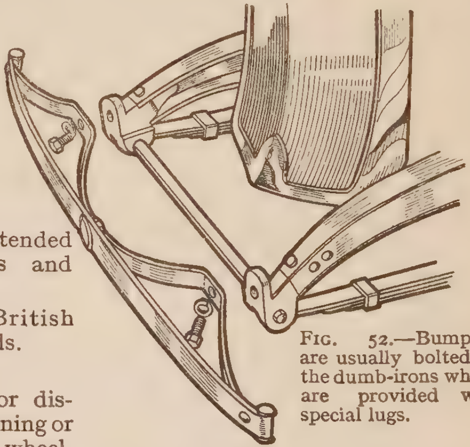


FIG. 52.—Bumpers are usually bolted to the dumb-irons which are provided with special lugs.

BURETTE.—A chemical measuring instrument used, among many other purposes, for determining the cubic capacity of an engine-cylinder.

BURNING OUT.—The local fusing of an electrical conductor or wiring due to the passage of an excessive amount of current through it. Burnt-out wires sometimes occur in the windings of magnetos, electric-motors and other instruments containing fine-wire coils

BURNING-POINT.—See *Ignition point.*

BURNISHING. — A process whereby a high polish is produced upon the surface of a metal or other material by means of a special rubbing treatment. The instrument used for this purpose is termed a *burnisher.*

BURNT GASES.—The gaseous products of the internal-combustion engine resulting from the ignition of the combustible mixture. Owing to their carbon monoxide content, they are highly poisonous when inhaled in any quantity.

BUSH: BUSH BEARING: BUSHING.—A ring of hard metal or of other material separately inserted into a metal wall in order to form a plain bearing. A bushing is generally used for light work only.

BUTTERFLY VALVE.—Name given to a type of throttle or carburettor-valve which, by the operation of an elliptical plate of metal (the "butterfly") controls the proportions of the mixture entering the cylinders.

B.W.G.—Birmingham wire gauge, the oldest of the wire gauges, now becoming obsolete. (See Tables at end of book.)

C

CABLE.—A generic term applying to an electrical conductor consisting of a number of separate wires twisted or laid together and exteriorly covered by a protective insulative coating. For example, the high-tension cable attaching to the plug terminals of the engine.

CABRIOLET.—Literally, a "covered carriage." Name descriptive of a type of car-body provided with a hood which can be closed down all round, thus converting the car into a completely enclosed one.

CADMIUM.—A bright, ductile metal which at ordinary temperatures can be drawn into wire and rolled into sheets. Its melting-point is 320°C. Cadmium is plated on to some articles from its solutions, and occasionally it is made use of as a base-plating for other metals such as silver, etc. Since, however, the introduction of nickel-chrome steels of the "stainless" type, cadmium-plating on car fittings has practically disappeared.

CALCIUM CARBIDE.—Chemical formula: CaC_2. A greyish, brittle material made by heating lime and carbon in an electric furnace. Used for the production of acetylene gas which it evolves copiously when treated with water.

CALCIUM CHLORIDE.—Chemical formula: $CaCl_2$. A white crystalline solid which rapidly absorbs moisture from the air and turns into a liquid. It is occasionally used as an anti-freeze, being added to the radiator water of a car in order to depress the freezing-point of the water, and so prevent the latter from freezing in cold weather. Its use, however, is attended with many objections, one being that it exerts a slow corrosive effect on metalwork.

CALLIPERS.—The name given to certain types of engineering compasses, the arms of which are specially formed for the accurate measuring of outside or inside diameters of tubes, cylinders, and other hollow articles.

CALORIE.—A term which enters into many heat calculations. A calorie is the amount of heat required to raise the temperature of one gram of water one degree centigrade.

CALORIFIC VALUE.—A term used to denote the amount of heat contained in a given quantity (usually one pound) of a fuel or any other combustible material. The term is a measure of the available energy of a fuel.

CALORIMETER. — An instrument in which the calorific values of fuels are determined.

CAM.—A piece of hard metal, usually steel, having irregular projections. It is mounted or formed on a shaft and it is designed on rotating to impart a reciprocating, lifting, or otherwise variable motion to another member such as a rod or bar. The best example of a cam, familiar to all motorists, is the cam of the valve-timing gear. This is usually pear-shaped, and its function is to set the valve-stem mounted above it into up and down motion, thus causing the valves to be periodically closed and opened.

CAMBER.—A curve, or convexity, upon a surface. The term is usually applied to the convexity of a road surface.

CAM LEVER: CAM ROCKER.—A metal lever which, being periodically raised and lowered by the revolution of the timing-cam, imparts an up and down movement to the valve tappet, thus opening and closing the valve.

CAM NOSE — The projecting portion, or " business end," of the cam which, in revolving, operates a lever-arm above it and so causes the valve-stem to be raised and lowered in due sequence.

CAM-SHAFT. — The shaft, or spindle, with or upon which the cam rotates. Cams are often formed in one piece with their cam-shaft.

CANTED.—Inclined, or tilted. The front wheels of a car are usually slightly canted in order to increase the car's steering stability.

CANTILEVER SPRING.—A type of car spring which is, in reality, half-elliptic spring attached to the frame in a reversed position. It has a bracket, or cantilever formation.

CAOUTCHOUC.—See *Rubber*.

CAP.—A cover, usually a metal one, which serves to protect working parts from dirt, dust, or other foreign matter.

CAPACITY.—The containing or absorbing power of an article or vessel. In motoring, the term is used principally in connection with engine cylinders, fuel and oil tanks, radiator systems and batteries. The cylinder capacities of engines are usually expressed in cubic-centimetres (c.cs.), or in litres. The capacity of an accumulator or battery represents, loosely speaking, the amount of electricity which it will hold, this value being customarily expressed in ampere-hours (amp.-hours). A battery of 40 amp.-hours capacity is capable of discharging at the rate of 1 amp. for 40 hours, or at 4 amps. for 10 hours, and so on in proportion.

CAP-NUT.—A nut which covers the end of the bolt to which it is attached, thus giving a better appearance to the finished part than an ordinary nut.

CARBON.—A chemical element which exists in three different forms : carbon, graphite, and diamond. Carbon occurs in all vegetable and animal substances, the carbon deposited within the engine cylinders being derived from the incomplete combustion of the carbon-containing fuel. Carbon is a most remarkable substance, and it has many varying uses, but to the motorist its presence in more than small amount within the cylinder head is undesirable.

CARBON DIOXIDE.—Chemical formula : CO_2. A heavy colourless gas, with a slight acid smell. Sometimes known as " carbonic acid gas." Carbon dioxide is the normal product of the combustion of carbon or carbon-containing substances in air. Hence, it is always present (to the extent of about 10 per cent.) in the exhaust gases of car engines. Although not directly poisonous, carbon dioxide suffocates by cutting off the supply of oxygen from the lungs. It should not be confused with carbon monoxide, which is one of the most poisonous gases known.

CARBON MONOXIDE.—Chemical formula : CO. A colourless and practically odourless gas which is excessively poisonous. It occurs in the exhaust gases of car engines in proportions varying from 0·1 to 0·02 per cent, it being mainly due to the presence of this gas that exhaust fumes are lethal in nature.

A garage atmosphere containing $\frac{1}{20}$ per cent of carbon monoxide will bring about speedy headache and eventual giddiness when breathed. $\frac{1}{5}$ per cent of carbon monoxide in the air will cause loss of consciousness, whilst an atmosphere containing 1 per cent of the gas will lead to rapid death.

For these reasons, therefore, care should be observed not to breathe an atmosphere contamined with the exhaust fumes of car engines.

See *Carbon dioxide.*

CARBON STEEL.—Name given to a variety of steels which contain from 0·5 to 1·25 per cent. of carbon without admixture of other metals.

Carbon steel is the "original steel" made long before the development of the more specialised "alloy steels."

CARBON TETRACHLORIDE.—Chemical formula : CCl_4. A pleasant smelling, heavy liquid which forms the active constituent of many portable fire-extinguishers carried on cars. It is non-inflammable and when scattered over a burning mass has the property of evolving heavy vapours which, by cutting off the supply of oxygen, extinguish the flames.

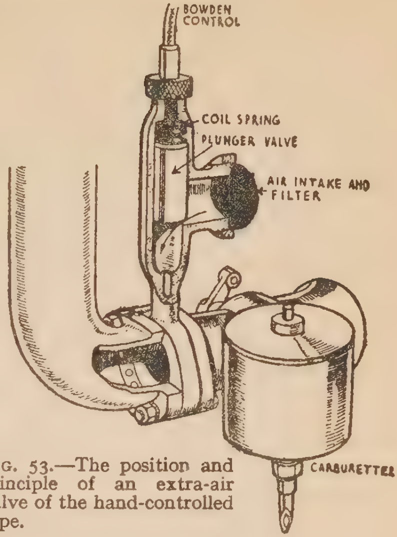


Fig. 53.—The position and principle of an extra-air valve of the hand-controlled type.

CARBORUNDUM. — Chemical formula : SiC. Silicon carbide. A dark, many-tinted material made by fusing a mixture of coke and sand at a high temperature in an electric furnace.

Carborundum, next to the diamond, is the hardest material known. In its many preparations and grades it is extensively used for grinding purposes in workshops and garages.

CARBURETTED AIR. — Air which has had a certain percentage of hydrocarbon vapour mixed with it to form an explosive mixture. The mixture drawn into the engine cylinders is really carburetted air.

CARBURETTOR.—A device for converting the engine fuel into a vapour and for mixing it intimately with the necessary amount of air to form an explosive mixture.

The term is derived from the expression *to carburet* (or *to carburise*), meaning to saturate or impregnate with carbon or carbon-containing vapour. (See also *Fuel Feed Systems.*)

CARBURETTORS EXPLAINED.—Carburation is so important to the satisfactory and efficient working of a petrol engine, that the motorist of an enquiring turn of mind will find a study of the subject of much interest. Such a study is, of course, not necessary for obtaining a great deal of pleasure from a modern car; in fact, there are a great many drivers who believe in "leaving well alone," and there is much to be said for this point of view. Motorists are usually very enthusiastic about their pastime, and like to understand the working of their cars, but one can take an intelligent interest in a car without "tinkering" with it.

Primary Functions.—All motorists know that the primary function of a carburettor is to supply a combustible mixture to the engine. To do this the carburettor has to measure the quantity of air passing, simultaneously measuring the corresponding amount of liquid petrol, and add the petrol to the air in the form of a fine spray, so that the petrol may vapourise readily. All of this could be done by the simple piece of apparatus shown in Fig. 54, if the engine speed and the load remained constant. For instance, the car might be climbing a stiff hill in top gear; the engine would then be working at full load, and the speed would be low, but when running down hill the speed may be high and the load quite small, while for racing the engine would be working at full load and high speed.

Mixture Strength.—The mixture strength should be about fourteen parts by weight of air to one part of petrol for best results. An engine will run on a mixture as rich as 8 to 1, but would not develop full power, and the petrol consumption would be very heavy, as a lot of the petrol would pass out *via* the exhaust, incompletely burnt. Petrol is a compound of hydrogen and carbon; the hydrogen would generally be completely burnt, but the

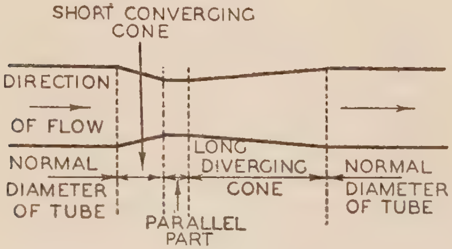


FIG. 55.—The Venturi is merely a tube of the form shown above.

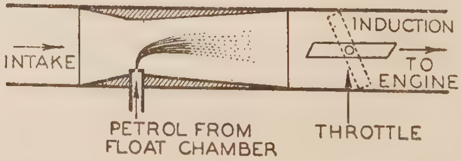


FIG. 54.—The Venturi applied to a simple Carburettor.

carbon content, instead of being burnt to carbon dioxide (CO_2), would, because it cannot find enough oxygen, only be partially burnt, to form carbon monoxide (CO), or even not burnt at all, in which case it would pass out with the exhaust as pure carbon, and would then be visible as black smoke. Incidentally, it is interesting to note that the carbon monoxide referred to is the gas that is responsible for exhaust gas poisoning; it is a very active poison indeed, and a car engine running with a rich mixture, in a small unventilated garage, would very quickly produce an atmosphere that could not be breathed without serious fatal results.

On the other hand, an engine will run on a weak mixture of 20 to 1, but in this case combustion would be slow, and not complete by the time the exhaust valve opens. This delayed combustion, in conjunction with excess of oxygen (also a result of weak mixture) is a frequent cause of overheating and burning of the exhaust valve. The mixture may even still be burning when the inlet valve opens to admit a new charge, in which case the new charge will be ignited immediately the inlet valve opens, thus producing "spitting back" in the carburettor. This is usually a sign of weak mixture, but anything that prevents the inlet valve from seating properly, such as a bent stem or a broken spring, may produce the same effect.

Some Facts and Figures.—Now 1 lb. of air occupies about 12½ cubic feet at normal atmospheric temperature and pressure, and 1 lb. of liquid petrol, about one-forty-fifth of a cubic foot; 14 lbs. of air will equal about 175 cubic feet, with which must be mixed one-forty-fifth of a cubic foot of petrol, so that the ratio of air to petrol, by volume, is practically 8,000 to 1. Therefore, when you buy one gallon of petrol, you will probably use up nearly 8,000 gallons of air with it. Fortunately air is cheap!

To measure the minute quantity of petrol required for each power stroke by mechanical means, such as a microscopic pump, for instance, would require extremely delicate apparatus, but fortunately it can be done much more simply by means of a tiny hole. The size of this hole needs to be adjusted to a considerable degree of accuracy, or, in other words, the size of the petrol jet is very important, as all motorists know; a little difference, not noticeable to the eye, will make a lot of difference in the performance of the engine.

The Pressure Over the Jet.—Besides the actual size of the jet, the pressure producing the flow has to be reckoned with. Obviously there would be no flow of petrol through the jet unless the pressure on the surface inside the float chamber was greater than the pressure at the top of the jet. A flow could be obtained by increasing the pressure in the float chamber, but it is much easier to reduce the pressure in the float chamber, but it is much easier to reduce the pressure in the region of the jet orifice by means of a venturi tube. This is generally referred to in connection with carburettors as a "choke" tube.

At first the tube converges somewhat gently to a smaller diameter, then there is usually a short parallel portion of the reduced diameter, after which the tube diverges very gradually to its original diameter. It is essential that the changes in diameter should occur gradually without any abrupt changes of section to cause eddy currents.

Action Fluid Through a Tube.—Now consider what happens to a fluid (either liquid or gaseous) flowing through the tube in the direction of the arrow. As the tube becomes smaller in diameter the fluid has to travel faster. This is obvious, because the same mass of fluid has to get through a smaller hole in the same time, therefore it must get through more quickly. When the speed of the fluid increases its momentum or kinetic energy is increased. Now energy cannot be obtained from nowhere, and the increase of kinetic energy in this case is obtained at the expense of the pressure energy of the fluid, with the result that the pressure at the narrow part of the tube is below that at the entrance, where the diameter is larger and the velocity less. After passing the narrow part or "throat," the gradually diverging tube slows up the fluid, until on regaining the normal diameter the velocity is the same as at the entrance to the converging part, and if the divergence is not too sudden, the pressure at the outlet is very little below that at the entrance. One might say that the diverging cone puts the brake on and the energy given up during the braking process builds up the pressure. The reduction of pressure in the throat is a measure of the amount of fluid passing; this explains our earlier reference to the carburettor measuring the air that passes through it.

This venturi effect is much used for water meters. It is only necessary to insert the venturi in the water main, the rest being a matter of arranging suitable pressure gauges together with integrating or recording mechanism, as may be required. If the reader would like to study this matter fully he is recommended to obtain a text-book on "Hydraulics."

The venturi is applied to a simple carburettor, as shown in Fig. 54, and may be either horizontal, vertical, or inclined, though the jet would be vertical in each case.

Jet Arrangement.—The jet arranged at the throat of the venturi, where the pressure is lowest. The petrol in the float chamber being subject to full atmospheric pressure, so the petrol spurts out of the jet and is broken up into a more or less fine spray. The increased air velocity caused by the venturi, therefore, serves the double purpose of creating a reduction of pressure, which makes the petrol flow from the jet, and at the same time breaks up the stream of petrol into a spray.

Fig. 54 shows a very simple form of carburettor, and further complications are necessary to render it suitable for car purposes. As shown, the carburettor would give a fairly constant mixture strength when running at or near full throttle opening, but when throttled down, the air speed through the venturi naturally falls off considerably, with consequent reduced suction on the jet. This is in itself quite a desirable state of affairs, but trouble arises, because the petrol flow falls off more quickly than the air flow, so that the mixture gets too weak to run the engine. This effect is due to friction and viscosity at the jet; it is not pronounced at full throttle when the air velocity through the venturi is high, but it is very marked when throttled and the air velocity is low.

In automatic carburettors, such as are usually used on cars, the mixture strength is generally kept nearly constant by means of some arrangement of compensator jets (either one or more) which come into operation progressively as the throttle is closed down, so enriching the mixture to normal strength. Much ingenuity has been brought into play over this matter, and each different make of carburettor has its own method of overcoming weakening of the mixture, and giving at least an approximation to constant mixture strength throughout its working range.

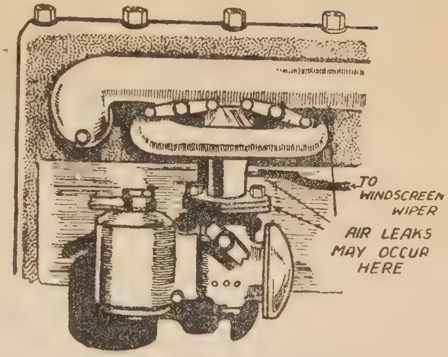


FIG. 57.—Points in the Carburettor System where Air-Leaks may occur.

The Straight Through Type.—The straight through type should, at full throttle, be more efficient than that provided with a Venturi, in the respect that it works with less drop of pressure between the atmosphere and the induction pipe. To cause the air to flow through the carburettor the pressure in the induction pipe must be below atmospheric; that cannot be avoided, but the less it is below, the better. Now the atmospheric pressure is in round figures 15 lbs. per square inch. A poor carburettor may require a difference of, say, 3 lbs. per square inch to pass enough air to the engine at full throttle, so that the pressure in the induction pipe may only be 12 lbs. per square inch. A good carburettor, however, might pass all the air the engine can take with a pressure difference of ½ lb. per square inch, in which case the pressure in the induction pipe would be 14½ lbs. per square inch, or, say twenty per cent higher than before. The greater the pressure in the induction pipe, the greater the amount of gas that will enter the cylinder, so we might expect something like twenty per cent increase.

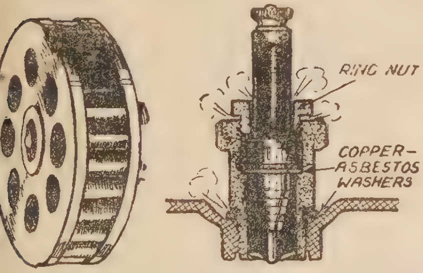


FIG. 56.—(*Left*) A useful Accessory (if not fitted as standard) is an Air Cleaner. The model shown (Vokes), being thin, does not interfere with the closing of the bonnet. It should be cleaned occasionally and treated with oil. (*Right*) Compression Leaks can occur not only between the Plug and Cylinder, but in the case of the detachable type, in the Plug itself. When dismantling, always replace washer and screw up tightly.

These figures are only given as an illustration, but they serve to show the advantage of a straight through venturi type of carburettor for racing purposes.

Fortunately all modern carburettors are provided with adjustments, so that the maker is enabled to adjust the instrument to the particular car. It must be remembered that a different setting is required for every car, even though of the same model and make. The jet size is not so important as the volume of fluid which can pass through it in a given time.

Carburettor Adjustment and Repair.—The troubles which beset the carburettor are comparatively few, and if the reader carefully studies the principles of carburation outlined earlier in this book, he should be able rapidly to locate it. The only parts which can wear are the needle valve, the toggle weights, and the throttle control. Before suspecting the carburettor in cases of engine stoppage, make certain that the ignition system is functioning, that the switch is " on," that there is petrol in the tank, and that the tap is turned on.

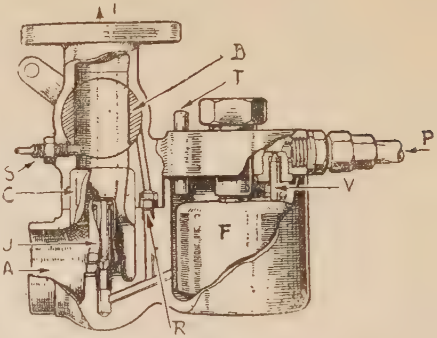


Fig. 59.—Part Sectional Diagram of the Vertical Solex Carburettor, in which A is the air intake, B the throttle barrel, F the float, I the induction pipe connection, J the jet, P the petrol pipe supply, R the slow-running jet, S the throttle stop, T the tickle, and V the needle valve.

Assuming that this has been done, inspect the vent hole in the petrol tank cap ; if this is choked up the trouble is due to air-lock. This hole must be kept clear, so that as petrol flows out, air can flow in. If this is clear (presuming no petrol in carburettor) the tap or pipes may be choked. If these points are O.K., examine the throttle mechanism to see that movement of the accelerator is transmitted to the throttle itself. A few spots of oil on the working parts often work wonders.

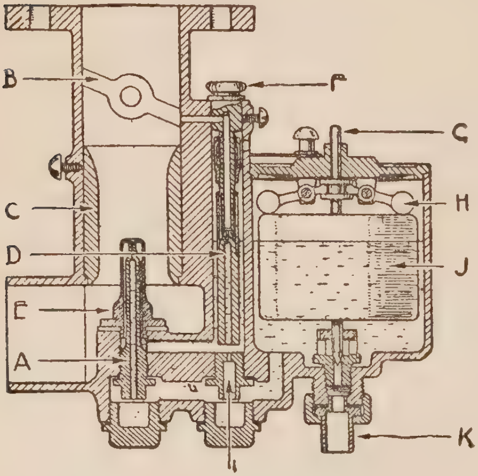


Fig. 58.—Cross section of the Zenith Carburettor in which A is the main jet, B the butterfly throttle valve, C the choke tube, D the slow-running jet, E the main jet cover, F the adjuster for the slow-running jet, G the needle valve, H the fuel supply union, and L the compensating jet.

Summary of Carburettor Troubles.—Needle collar bent out of truth on needle ; float touching inside of float chamber ; counterweight pins bent ; counterweight pin hole in cover not equidistant from centre ; counter weights not free between supporting webs ; ends of counter-weights binding on neck or rim of needle collar ; counterweights, pins, and pin holes corroded as the result of using unsuitable petrol or through the effects of sea-water ; one

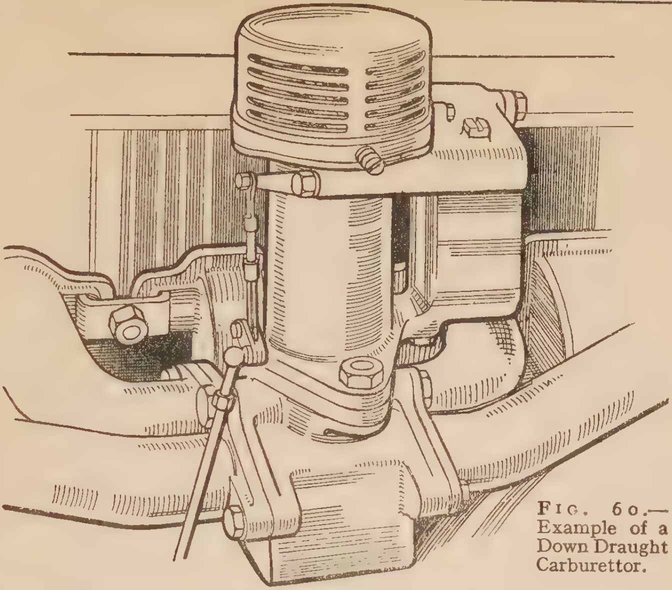
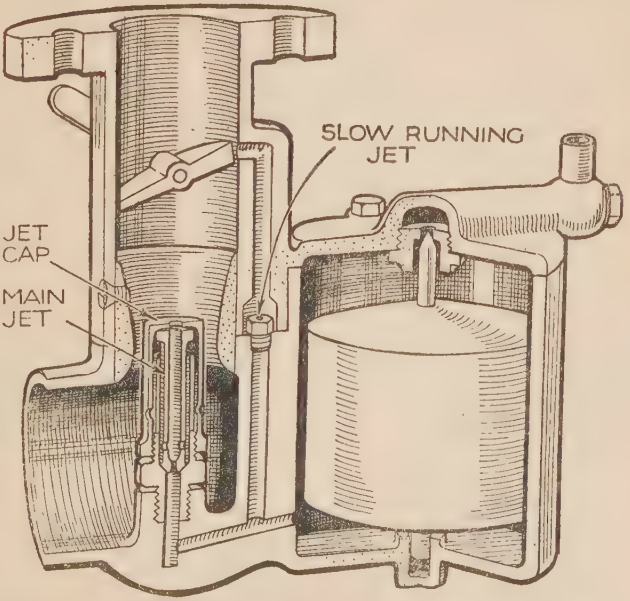


FIG. 60.—Example of a Down Draught Carburettor.



SLOW RUNNING JET
JET CAP
MAIN JET

FIG. 61.—Example of a Vertical Carburettor of the Solex Type.

counter-weight hanging lower than the other causing float to tilt and bind on needle; counterweights not identical in shape; cover distorted or not seating properly in top of float-chamber; needle guide hole in cover not central or too small; needle bent or damaged through being held in vice or pliers; bottom of float-chamber bent through, using excessive force on union-nut.

The Needle.—When the needle is worn at the conical point, that part, in fact, which forms the valve, unless a lathe is available, it is advisable to replace the needle complete. The small collar operating the toggle weights is soldered on, and in refixing this to the new needle, care should be exercised to make sure that it is fixed the correct distance from the point. This should be ascertained by measuring the old needle. The position of this grooved collar, of course, fixes the petrol level in relation to the jet; raising the collar will lower the level, and lowering the collar will raise the level. The correct level is about $\frac{1}{32}$nd of an inch below the top of the main jet. If the old needle is reground or sharpened in a lathe with a dead smooth file, the collar should be raised on the needle a distance equal to the amount of material moved. Adjustment to the height of the position of this collar will also be necessary if the toggle weights have flats worn on them. These flats appear after the car has done 30,000 miles or so, and as they wear, the petrol level is raised, thus increasing petrol consumption, and causing rich mixture. Before altering the collar to compensate toggle weight wear, the weights should be reversed by unpinning them from the carburettor cover.

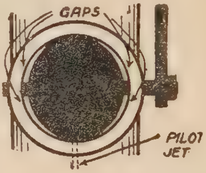


Fig. 63.—How the Tick Over may be affected by a worn butterfly throttle valve. Leaks occur although throttle is "closed."

Repairing the Float.—Sometimes a float becomes punctured, allowing petrol to leak inside, thus increasing its weight and raising the level automatically. The leak may be traced by immersing the float under hot water and noting where the bubbles issue from it. Reverse the float in the water so that the leak is at the bottom; this will drive the petrol out. Then lightly solder up the leak, carefully scraping away any superfluous solder, so that the

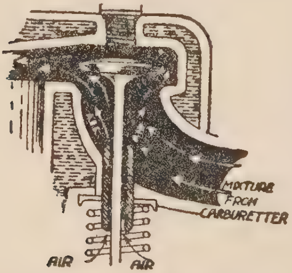


Fig. 62.—How a Weak Mixture results from worn Bearings.

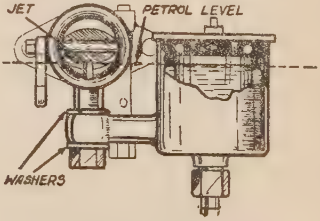


Fig. 64.—On some Carburettors, if the Washers are not replaced, the Petrol Level may be altered.

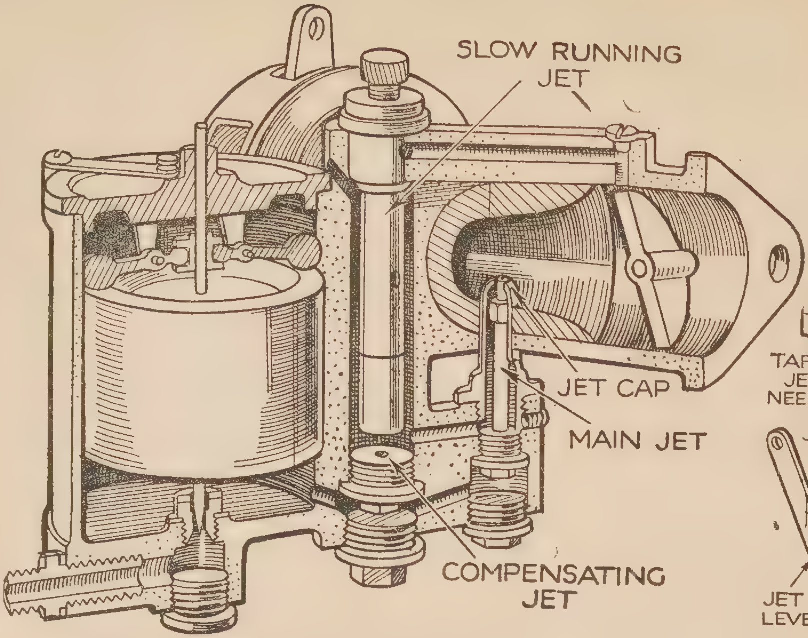

SLOW RUNNING JET
JET CAP
MAIN JET
COMPENSATING JET

FIG. 65.—A Horizontal Carburettor similar to the Zenith.

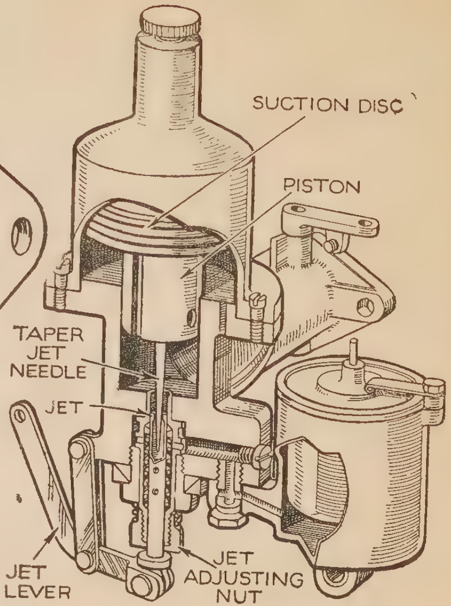

SUCTION DISC
PISTON
TAPER JET NEEDLE
JET
JET LEVER
JET ADJUSTING NUT

FIG. 66.—A Single Jet Carburettor—The S.U.

weight of the float is not materially increased.

Repairing the Throttle.—Throttles are of two types, the disc or butterfly throttle, and the barrel throttle. Wear usually takes place at the spindle or bearing holes of butterfly throttles, and the parts here should be renewed.

Cleaning the Carburettor.—It is advisable to clean out the carburettor periodically, scrape out the gauze and filters, taking care that all washers on the jet seatings are replaced, otherwise the petrol level will be altered. Do not endeavour to poke out the jet with pieces of wire, otherwise the jet hole, the diameter of which is important, will become enlarged.

Air Leaks.—Defective carburation is often due to worn valve sides, and these should be inspected before suspecting the carburettor. A weak mixture may also be due to burnt or pitted valves, sparking-plug washers not making an air-tight joint, windscreen wiper attachment insecure, carburettor flange washer broken or slack, worn pistons, centre part of sparking-plug loose. Reference should be made to Figs. 58 to 66.

CARDAN SHAFT.—A term which is applied to any shaft transmitting power. More particularly, it denotes the main power-shaft from the gearbox of a car to its back-axle.

From *Girolamo Cardano* (1501-1575), an Italian physicist who invented a shaft with flexible joints.

CARNOT'S CYCLE.—The name given to the cycle of operations which would take place in an ideally perfect engine in which friction was non-existent and heat-loss unknown, and in which the working gases possessed ideal properties—all of which conditions are, of course, quite impossible of attainment, but which are, none the less, of much theoretical importance.

The name of this theoretical cycle is derived from *Sadi Nicolas Leonhard Carnot* (1796-1832), son of one of Napoleon's celebrated generals, who, in 1824, first enunciated it.

CARTRIDGE FUSE.—A form of electrical fuse in which the fusing element is contained in a non-inflammable cartridge-like case. Used sometimes in car-wiring circuits.

CASE-HARDENING.—Term referring to a process of giving a hard surface to iron and steel articles, thereby making them more able to resist wear, less liable to rust, and capable of taking a better polish.

Case-hardened articles have their interiors unaffected by the hardening process. Consequently they are not rendered brittle and are, therefore, not liable to fracture through mechanical shock or vibration.

CASEIN.—A plastic material of unknown composition manufactured from curdled milk and marketed under various trade-names for the manufacture of small ivory and horn-imitation fittings for the door-handles of cars as well as for a multitude of other purposes.

Originated in 1909, when a Russian student, V. Schutze, of Riga, patented a method of obtaining hard moulding material from curdled milk.

CASTELLATED NUT. — See *Castle Nut.*

CASTING.—Term given to an article which has been produced by pouring molten metal or other material into a mould and allowing it to solidify. Many parts of cars are made in this way—cylinders, gear-boxes, etc.

CAST-IRON.—This well-known material from which cylinders and other castings are made is obtained from pig-iron, which is the product derived from the smelting of iron ores. Pig-iron contains usually from 3 to 4·5 per cent. of carbon. It is re-melted and, in the presence of hot air, loses a portion of its carbon, the resulting product containing about 2·5 per cent of carbon and being known as *cast-iron.*

Cast-iron is hard, and it has a good tensile strength. It liquifies with ease at comparatively low temperatures, and thus it can be run into moulds and cast into any required shape.

Cast-iron varies considerably in carbon content, the higher the carbon content the harder, the more brittle and the weaker the cast-iron. For cylinder-casting purposes a fine-grained cast-iron of uniform and medium carbon content is chosen.

CASTLE NUT.—An hexagon nut having a series of grooves cut in its top face. The nut can thus be secured to the bolt by means of a split-pin passing through the grooves and through a hole drilled in the bolt. A nut thus secured cannot come loose by vibration. (Same as *Castellated Nut.*)

CASTOR OIL.—A thick, pale yellow vegetable oil, obtained by expressing the seeds of the Castor Oil plant. It forms an important ingredient of some engine lubricating oils owing to the " body " which it imparts to them.

CATALYTIC IGNITION. —Term referring to certain ignition systems which have been experimentally trued out from time to time. These depend upon the property possessed by some substances of glowing under the influence of hydrocarbon vapours. Platinum, palladium, osmium, and similar rare metals are examples of " catalytic substances " which possess this property.

CAULK.—To render a tank or pipe liquid-tight by closing up its seams by hammering them together with or without the interposition of various packing materials.

C.CS.—The recognised abbreviation for *cubic-centimetres*, which see.

CELL.—One of the component parts of an accumulator or battery. A cell is the minimum unit for supplying current.

CELLULAR RADIATOR.—See *Honeycomb radiator.*

CELLULOID.—A synthetic material manufactured in varying degrees of transparency. First introduced in 1869 by the brothers Hyatt. Celluloid is composed of pyroxyline or guncotton dissolved in a suitable solvent and mixed with camphor, certain pigments (if required), and other substances which reduce its inflammability.

For side-screen use, celluloid sheets, which are manufactured under pressure, often have traces of materials added to them for the purpose of filtering out the ultra violet and violet rays of bright light.

CELLULOSE FINISH. — Name applied to a finish given to car bodies by a process of spraying them with specially-treated cellulose or cotton material dissolved in certain solvents (such as acetone, alcohol, ether, etc.) so as to form a varnish which may be used either alone (in its clear, transparent state) of mixed with various pigments for colouring purposes.

Carefully applied, the cellulose paint or varnish dries with a fine, streakless, hard and glossy surface. These instructions, which follow, have been prepared specially for owner-drivers, who by following them, can impart a professional finish.

CELLULOSING AND TOUCHING UP.—It is not generally realised that the modern two- or four-seater family car can be re-cellulosed for a very modest outlay due to the fact that a very efficient spraying apparatus, which only costs 5*s*., is now marketed by several manufacturers, one of the best being that supplied by the makers of "Chemico" Spraying Cellulose. A useful type is their No. 3 "Sprayon" Gun, and provided a good motor foot-pump is available, nothing more is required except a few tins of "Chemico" Spraying Cellulose and a certain amount of energy. Full instructions are sent out with every gun, and these should be studied carefully in order to obtain the desired results.

Before actually applying cellulose, certain preparations are absolutely necessary. First of all the condition of the existing paintwork must be considered. If it is in good condition and not too badly chipped or dented, spraying can be commenced after the car has been cleaned and rubber over with petrol. On the other hand, if the paintwork has gone too far it should be removed, and this is soon done with "Nameloff" Paint Remover, which is liquid and non-inflammable.

Next the garage must be swept out, otherwise dust will rise and settle on the new paintwork before it is dry. Windows should then be shut, and if there is plenty of light all doors should also be closed. It is also a good plan to remove all loose fittings from the car, and in the case of an open tourer the hood, and if possible the windscreen should be removed and stored away in a dry place.

When the car is ready the gun should be prepared and tested. The best method of testing is to connect the air-line (supplied with the gun) to the foot pump, and attach a ½-pint tin of "Chemico" Cellulose Thinners to the gun itself. Then pump sufficient thinners through to ensure a free passage for the paint. Now in place of the tin of thinners attach a ½-pint or pint screw-cap tin of "Chemico" Spraying Cellulose in the chosen shade and spray this on to a sheet of metal to make certain that the gun is atomising properly, and that you can swing the gun steadily from right to left whilst working the foot-pump.

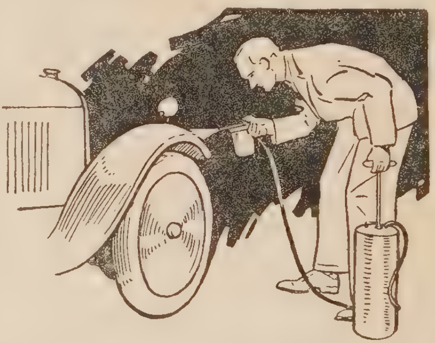


Fig. 67.—The spraying "gun" must be "fed" from an air reservoir. Many "guns" now available can be operated from a tyre pump.

Actual spraying can now be started, and work should be commenced at the top of the body, gradually working downwards until the whole is covered with one coat. When spraying, the gun should be held at least six inches away from the surface and it must be kept moving in one direction or another, otherwise the cellulose will run.

The first coat should be allowed at least two hours to set, after which it should be rubbed down with "Wet or Dry" emery paper (used with cold water) before the second or final coat is sprayed on. When the final coat has set hard it will need rubbing over with "Chemico" Cellulose Leveller No. 10, in order to level the high spots and any other blemishes which may have been unavoidable during the spraying process.

"Chemico" Spraying Cellulose dries quickly and sets with a durable finish. It can be obtained in about ten different standard shades, which can be readily mixed to give other colours.

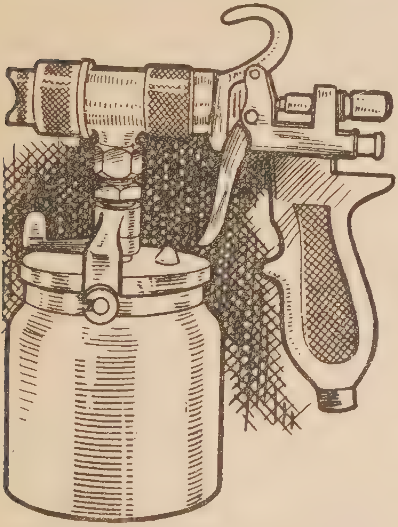


FIG. 68.—A very convenient type of "gun" for spraying the car with enamel or cellulose. It must be used in conjunction with a small air container and a foot-pump.

Re-cellulosing a Damaged Part.—Sometimes a small patch of paint becomes chipped off the edge of a wing. The bare metal is usually rusty, and this rust must be removed before the next process can be started. Take plenty of care over removing all traces of rust otherwise the paint will only lift again.

For cleaning rusted metal use emery paper, and use it dry. Smooth off the sharp edges as much as possible, and then remove all dust. When this is done the damaged part is ready for the next process.

Next fill up the damaged area with stopping. To use the stopping get an ordinary table-knife, the blade of which bends easily. Dip the knife into the tin and then rub the blade over the damaged part. This will leave a coating of stopping over the bare metal, which, of course, is done to raise the unpainted surface up to the original level. The coat of stopping will appear rough, but this is finally levelled off during the next process. Allow at least 2 hours for the stopping to set hard. Fill in carefully. Cellulose will only give perfect results on an even surface.

Flatting the Cellulose Stopping.—When the stopping has set it is ready to be "flatted," or levelled off, to the surface of the surrounding paintwork with emery paper which has been dipped in a cup of warm water. The emery paper is used wet for flatting in order to prevent scratching the surrounding painted surface. Upon this work depends the success or otherwise of the repair. After rubbing briskly over the stopping, wipe away the deposit and then rub your fingers over the surface to see whether it is quite smooth. If not, continue the "flatting" until you are satisfied you have a perfectly smooth surface before commencing to apply the new paint.

Spraying the New Cellulose.—Hold the "Sprayon" Gun about four or five inches from the prepared surface, draw back the handle, and then push forward as you would when you use a tyre inflator. About three pumps will cover the stopping, and the new paint should be left to dry for at least fifteen minutes.

When spraying on to a vertical surface, be careful not to apply too much paint, otherwise it will run.

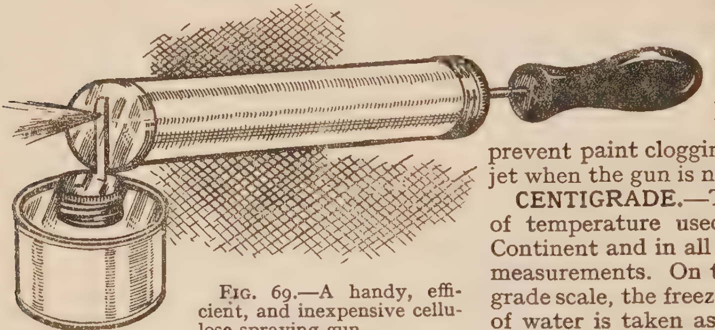


Fig. 69.—A handy, efficient, and inexpensive cellulose spraying gun.

Although spraying cellulose is quick-drying, give it a fair chance by using it in a quiet part of the garage, where the wind will not stir up the dust. It is best to test the gun on an old piece of metal before covering the actual work.

Flatting the First Coat.—While the paint on one part of the car is drying you can move on to another part where you have gone a step further. After spraying the first coat the surrounding surface will appear rough. This has to be smoothed down before you apply a second or even a third coat. This levelling is done by using the emery paper wet as in operation No. 3. The best method of using emery paper on a flat surface is to wrap it round a piece of wood so as to avoid scratching the surrounding paintwork.

This flatting down also produces a better surface to take the second coat. Before applying the second coat be sure and clean the surface.

One more word of advice. Always keep the gun perfectly clean. When you have finished work for the day, remove the container from the gun and replace the cap. Then dip the tube on the "Sprayon" Gun into some "Chemico" Cellulose Thinners (4-oz. tins 9*d.* each) and pump vigorously for a few seconds. This will prevent paint clogging up the jet when the gun is not in use.

CENTIGRADE.—The scale of temperature used on the Continent and in all scientific measurements. On the centigrade scale, the freezing-point of water is taken as zero, its boiling-point being 100. Abbreviation : °*C.*

CENTRE PUNCH.—A small steel tool used to make indentations in a piece of metal or other material in order to indicate the centre of a future hole.

CENTRIFUGAL FORCE.—The reaction of a body against a force which compels it to move in a curved track. The principle is made use of in most forms of governors. It is the operation of this principle, also, which causes a car to swing outwards at a tangent when a driver attempts to negotiate a greasy corner at too rapid a pace.

CENTRIFUGAL SPEEDOMETER.—A type of speedometer in which the speed-indicating movement of the pointer is obtained by means of a small ball-governor acting under the influence of centrifugal force.

CHAUFFEUR.—French word for a motorist. It means literally a *stoker*, or a *fireman*, and in the earliest days of motoring it was used on the Continent as a term of derision.

CHAIN.—A series of links, usually of metal, passing through one another and used as a means of transmitting power from one pinion or toothed wheel to another.

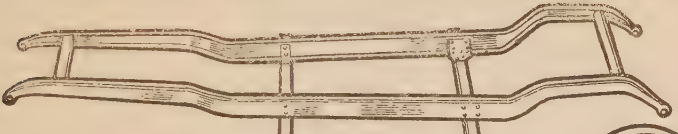


FIG. 70.—A typical light car frame of the simple type.

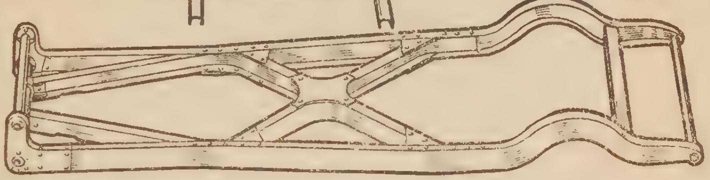


FIG. 71.—Light-car frame with cruciform bracing, giving greater rigidity.

CHAIN DRIVE. — Term used generally to denote the transmission of power from one sprocket-wheel to another by means of a chain, as, for example, in some magnetic drives.

The term is also applied in a more restricted sense to the final drives of some commercial vehicles consisting of a roller-chain transmitting power between the gearbox and the rear wheels.

For ordinary cars this system is obsolete, but commercial lorries, etc., which embody it are still to be seen.

CHAMBER.—In motoring technics this term usually applies to the combustion chamber, the crank chamber, or the valve chamber of the engine.

CHAMFER.—Term used to denote a bevelled or sloping face formed on the edge of a piece of metal or other material, usually for decorative purposes.

CHARGE.—The mass or volume of fuel vapour and air which is sucked into the cylinder of an engine by the induction stroke of the piston.

The amount of energy available for release which is stored up in an accumulator.

CHASSIS.—French term originally used to denote the frame part only of a car. The word nowadays signifies the entire running assembly of a car minus only its bodywork.

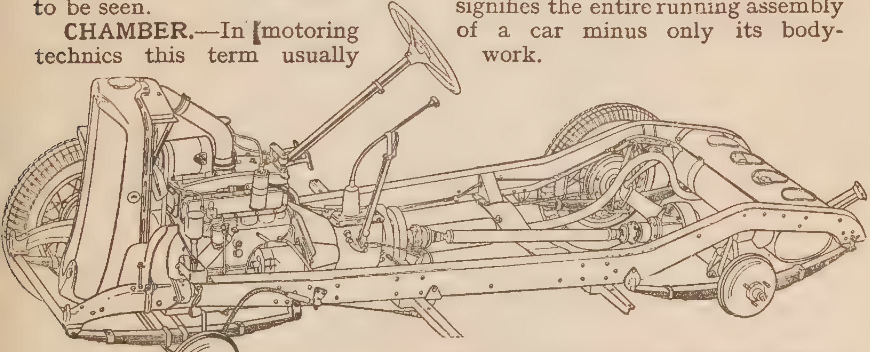


FIG. 72.—An excellent example of good Chassis Design—The Hillman Minx.

A TYPICAL CHASSIS

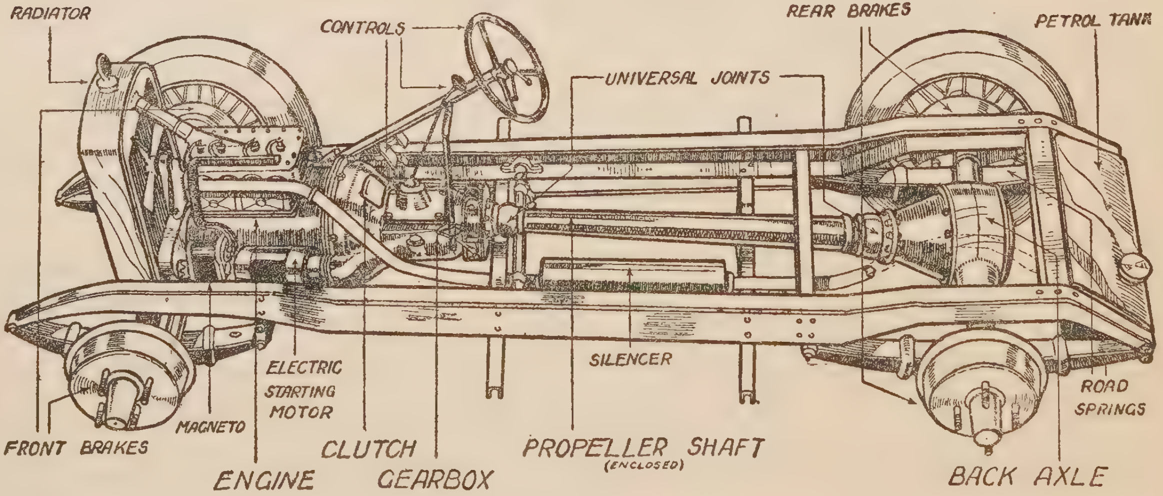

RADIATOR
CONTROLS
REAR BRAKES
PETROL TANK
UNIVERSAL JOINTS
FRONT BRAKES
MAGNETO
ENGINE
ELECTRIC STARTING MOTOR
CLUTCH
GEARBOX
PROPELLER SHAFT (ENCLOSED)
SILENCER
BACK AXLE
ROAD SPRINGS

FIG. 73.—The Chassis Layout of a Car showing the principal Components. Each of the Components is explained in detail in this section.

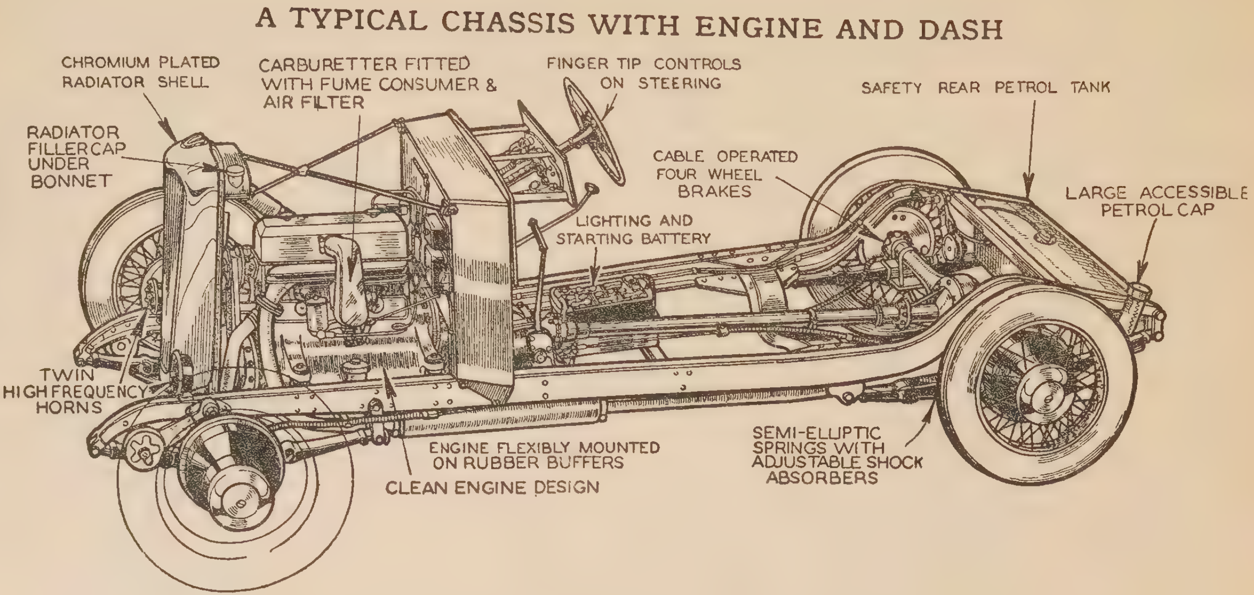

A TYPICAL CHASSIS WITH ENGINE AND DASH
CHROMIUM PLATED RADIATOR SHELL
CARBURETTER FITTED WITH FUME CONSUMER & AIR FILTER
FINGER TIP CONTROLS ON STEERING
SAFETY REAR PETROL TANK
RADIATOR FILLERCAP UNDER BONNET
CABLE OPERATED FOUR WHEEL BRAKES
LARGE ACCESSIBLE PETROL CAP
LIGHTING AND STARTING BATTERY
TWIN HIGH FREQUENCY HORNS
SEMI-ELLIPTIC SPRINGS WITH ADJUSTABLE SHOCK ABSORBERS
ENGINE FLEXIBLY MOUNTED ON RUBBER BUFFERS
CLEAN ENGINE DESIGN

FIG. 74.—A typical Chassis, showing the disposition of the various units on a modern Layout.

CHASSIS LUBRICATION.—The lubrication of the chassis is a most important part of the maintainance of a motor car, and is very often neglected by the owner-driver. By chassis lubrication is meant the oiling and greasing of all those parts which are not lubricated by the engine, gearbox, and rear axle oil and which require manual attention at intervals.

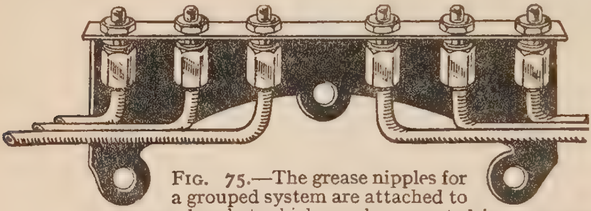


FIG. 75.—The grease nipples for a grouped system are attached to a common bracket which can be mounted in a convenient position.

On the modern car the grease nipple has replaced the old grease cup which was given two turns every few hundred miles or so. With a grease gun, lubricant can be injected with great force into the parts to be lubricated, thus making sure that no two surfaces are running " dry. " Just as there should always be a film of oil between any two moving parts of the engine, so this film should be present between the spring shackle bolts and their bushes, the universal joint bearings and a large number of other points where there is movement.

There appear to be very many lubrication points on a car, when the oiling and greasing diagram in the instruction book is consulted. It is only a 15 minutes job, however, to attend to them all. All greasing should be carried out with a system. It is useless to go round the various nipples with a grease gun, operating on one here and one there. Such a haphazard method is bound to lead to a number of points being missed. When a car is first purchased the chart should be consulted and a regular sequence of greasing adopted. It will soon be memorised and will obviate the necessity of consulting the chart every time. It is simplest to start at say the front off wheel and work round the car until the starting point is reached again. The number of greasing points should be counted so that if one is missed, it can be traced.

Grouping the Nipples.—A very useful method of facilitating greasing is by grouping the nipples. The job is not beyond a useful amateur and needs no special tools or skill. By this method the inaccessible greasing points are connected to a central plate by pipes, so that it is only necessary to operate the grease gun in very few places in the car. Nipples such as

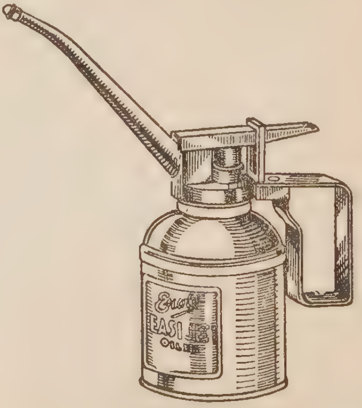


FIG. 76.—A useful force-feed oil can.

those at the front of the front springs and at the rear of those at the back of the car are already accessible and do not need grouping. Other parts are not so easy to get at without lying under the car, and these are well worth the trouble of grouping. The rear axle nipples are a case in point. There are usually greasing points on the spring chairs, the brake-gear and a number of other places, all of which are difficult to get at. All these can be grouped on the rear axle casing and, by cutting a trap door, where one does not already exist, under the back seat, all the nipples can be lubricated without getting dirty. Further, the nipples so placed are kept much cleaner. The material for grouping these points is obtainable from the grease-gun manufacturers who supply it in a very convenient form. The piping is in convenient lengths and fits into the nipples with a solderless joint. Suitable plates with the grouped nipples fitted are available to attach to the car. No other tool than a spanner and a file to cut the piping is required.

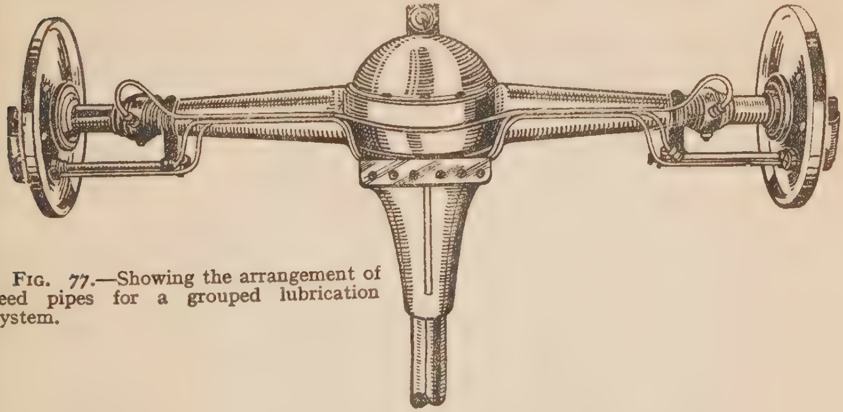


FIG. 77.—Showing the arrangement of feed pipes for a grouped lubrication system.

The illustration on this page shows how the system can be applied to a Morris Oxford. It will be noted that the grouping plate fits the three bolts on the top of the axle casing and that all the greasing points are brought conveniently under the rear seat.

In the case of a "floating" part, like a front or rear axle, the grouping plate must be fitted to a part of the axle itself or the movement will fracture the pipes. In cases where this is not possible a flexible pipe is available. The total cost of fitting a car with the grouping system varies, but should not exceed about £2. The parts for the Morris rear axle illustrated cost only 15*s*.

The Type of Lubricant.—Another very important point in chassis lubrication is the type of lubricant to be used. The grease ways are drilled through the various parts and, if these channels are blocked up with hard grease, the lubricant will not be able to reach its goal.

Cheap greases which go hard in use are just as useless as those which are too fluid when warm. A grease which is too soft will soon be squeezed out of the bearing, and the constant up and down stresses in a part like a spring shackle will soon splash the lubricant out on to the road. A good grease such as is made by our foremost manufacturers is neither too hard nor too soft, and will not cake with low temperatures nor run on a hot day. It is also very adhesive and so is not lost through the hammering motion of highly stressed shackles and other bearings.

Where grease is used in a universal joint housing, it is important also that one of the correct consistency is used. If the grease is too thin it will run out of the joint and leave it dry. On the other hand if it is too hard, the joint will make a track in it and will not obtain proper lubrication.

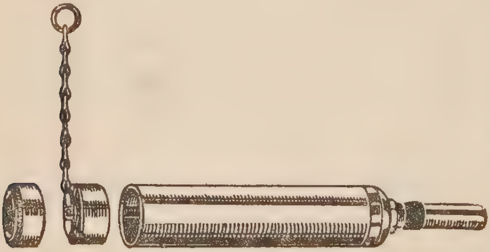


FIG. 78.—A popular type of grease-gun, show ing the cork plunger.

A special grease is also made for water pump glands. The water in a radiator is very near boiling point and any ordinary grease will not resist the high temperature without breaking down. This fault means that the gland will not be water-tight and a leak will probably take place.

When using a grease-gun, sufficient grease should be injected to push out all the old lubricant and fill the part with new. In a part like a spring shackle, this can be done by operating the gun until the new grease is seen to exude from the sides of the spring eye. Be careful to wipe all dirt from the grease nipple before applying the gun or the nipple will be damaged and stopped up by the grit being forced into it. The gun must be applied straight on the nipple or the grease will escape at the side instead of passing through it. With the assistance of a spanner, the nipples can be turned into a convenient position so that the gun can be easily applied. As they are made with a tapered thread they will remain tight in a number of positions.

Where the grease will not pass into the part, the trouble is usually that the channel has become blocked up. This means that the part must be taken down and the obstruction cleared, or a special tool called "Biffit" used which will clear the passage. These tools cost only a few shillings and can save an enormous amount of work.

Cleaning the Springs.—The front and rear springs on every car should be taken completely to pieces once every year and thoroughly well cleaned and lubricated. The smooth riding of the car will be very much improved by this attention and spring breakage will also be prevented. It is also useful to lubricate the springs without taking them off the car at intervals, and this especially applies to the winter months when water and mud get between the leaves. The best method of doing this is to jack up the car by fitting the jack to the chassis and winding it up fairly high. The leaves of the spring will then be separated to some extent and, if a thin chisel is driven between them, grease can be applied with the blade of an old knife. Here again it is important that only the best quality grease is used, as a quality which runs or is washed away quickly will make all the work done useless.

There are still a few points on a car which require attention with an oil can. Joints in the brake mechanism and the various operating levers will benefit with a little oil at intervals. For this purpose a pressure oil can is a great convenience as, in addition to the force with which the oil can be applied when necessary, the long spout makes the parts easy to reach.

Chassis lubrication is in itself an economy. The bearings lubricated with the grease-gun will very soon wear if allowed to get dry and are frequently costly to replace. This is not due to the high cost of the replacements but to the large amount of labour involved.

CHATTERTON'S COMPOUND.—A pitch-like insulating material composed of Stockholm tar, resin, and gutta-percha, usually supplied in stick-form. It is used as an electrical insulator in repair work, etc., being readily melted by heat.

CHECK VALVE. — See *Non-return Valve.*

CHEVRON BEVEL-WHEEL.—A bevel-wheel, the teeth of which are cut in arrow or herringbone formation.

CHOKE TUBE.—A small metal tube of narrow bore which, when fitted inside a carburettor, causes an increase in the velocity of the fuel mixture which passes through it.

CHROME-STEEL.—Name given to a class of hard and tough steels containing small amounts of chromium. Chrome-steel has a high tensile strength. Certain chrome-steels are so hard that they cannot be worked with ordinary hard steel drills.

Chrome-steels are used sometimes in car constructional work.

CHROMIUM.—A hard, bluish-grey metal of high-melting point and very resistant to atmospheric oxidation. On account of this fact it is now plated extensively on the surface of other metals used for car fittings, ornamental purposes, etc.

Chromium is also an important ingredient of certain alloy steels, to which it imparts toughness and strength.

CHUCK.—The portion of a lathe which grips articles and supports them whilst they are being rotated.

It is applied, also, to the jaws of drills which hold the " bit."

CIRCUIT.—Used as an electrical term, the word refers to the path which an electric current traverses in passing from one pole of the battery, dynamo, or other electrical-generating device to the other.

When this path is continuous and uninterrupted the circuit is said to be *closed* ; when the circuit is broken at one or more points it is said to be *open.*

CIRCULATION.—Term used in motoring in connection with the circulation of water from the water-jacket and radiator of the engine.

CLOVER-LEAF BODY.—Name applied to describe the bodywork of a car which seats three people, the third person being provided with a seat at the rear of the car.

CLUTCH.—A device for connecting and disconnecting two revolving parts together so that the revolutions of the one member may be taken up or relinquished by the other member at will. In automobile construction clutches are usually frictional devices.

CLUTCH ADJUSTMENT.—Gear changing on a car is rendered difficult if the clutch is not in proper condition. If it engages fiercely or disengages slowly the change of gear will be difficult to make. Most troubles in regard to the latter defect are due to lack of efficient lubrication, or the use of grease, where oil should have been used. The free-shaft of the clutch, which drives the first wheel in the gearbox, should be quite free. This is the most important point in connection with easy gear-changing. It should be kept well lubricated, both in the gearbox end and in the spigot bearing, at the end inside the flywheel. This bearing is almost always fitted with a screw-down greaser, or with a connection for a Tecalemit grease-gun. It is often neglected because it is generally out of sight; but it should be lubricated every thousand miles, if good clutch-action and easy gear-change is desired.

The illustration shows a conventional type of plate-clutch in diagrammatic form, and in the disengaged position. A is the engine flywheel, faced with an annular-ring of friction fabric B. A second ring of friction fabric is mounted on a disc C, which can move endways in the recess in the flywheel but cannot rotate relatively with it because it is mounted on, and engages, a series of teeth D, inside the flywheel-rim. When pressed into the flywheel it nips the thin steel disc E, between the friction fabric faces of B and C.

The disc E is mounted on a boss E_1, which can slide along flutes, or splines, along the shaft F, but cannot rotate upon it. This shaft F drives the primary shaft and wheel in the gearbox, and when disc C is pressed so as to nip disc E between itself and the flywheel disc B, the flywheel must drive shaft F. To get this nipping pressure a series of helical compression springs M are fitted in pockets in the outer plate N, which is bolted to the flywheel and rotates with it. The springs press plate C up against the driven disc E, and E against the flywheel disc B, so as to transmit the drive from the flywheel to the shaft F, through the disc E and the splines on the shaft F. Alternating with

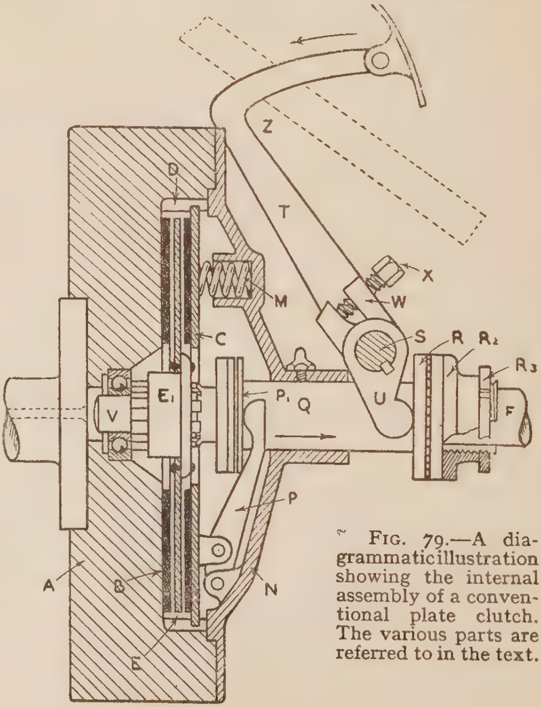


FIG. 79.—A diagrammatic illustration showing the internal assembly of a conventional plate clutch. The various parts are referred to in the text.

the springs around the outer plate N are levers P, pivoted on disc C, and on the cover-plate N, with their free end abutting against a ball thrust collar P, at the end of a sleeve Q, which slides along shaft F, and at its outer end carries a second ball-thrust bearing R, by means of which it can be pulled back. When pulled back it pulls the ends of levers P and, their ends being fulcrumed in the outer casing of the clutch, they pull the plate C back against the pressure of the springs M, and so release the driven disc E and disengage the clutch, which cannot then transmit the drive from the flywheel to the primary gear-shaft F. The clutch-pedal lever T, is fixed to a cross-shaft S, the end of which carries the short, double lever U spanning the sleeve Q, with its ends butting up against the face of the ball-thrust collar R. Depression of the pedal pushes the sleeve Q back in the direction of the arrow, pulls the ends of levers P, and so pulls the plate C against the pressure of the springs M in the flywheel-cover plate N, and disengages the clutch.

Pedal-throw Adjustment.—The clutch-pedal should always be able to come so far back as to leave contact with the face of the ball-thrust bearing R, so that there is nothing to prevent the springs pressing the plate C up tightly and so engaging the clutch. Wear on the clutch fabric discs may cause sleeve Q to move to the left, and it would bring the face of the thrust-collar R nearer to the double-lever U if the clutch-pedal T could not move up through some obstruction such as a floorboard dotted. The clutch then would not be fully engaged and would slip. It is necessary to see that the pedal can come back to a position where it is quite free, and can move quite easily for about an inch at the pedal end without in any way affecting the clutch. If the ball-bearing V at the end of the shaft F is not well lubricated, the shaft will have a tendency to turn with the flywheel, which will be trying to drive it. This will make a change of gear difficult when changing to a higher gear where we want to slow down shaft F, and with it the primary drive in the gearbox.

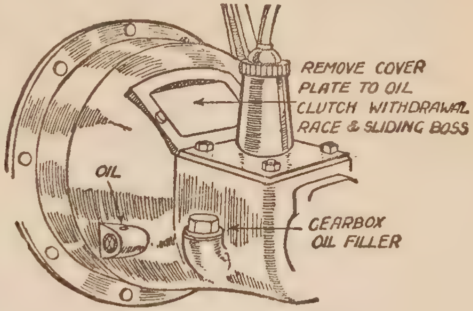

REMOVE COVER PLATE TO OIL CLUTCH WITHDRAWAL RACE & SLIDING BOSS
OIL
GEARBOX OIL FILLER

Fig. 80.—Illustrating the main points at which lubrication is required at regular intervals.

Importance of Lubrication.—Often this bearing is lubricated from the engine lubrication system, through a hole in the crank-shaft shown dotted, and in such case no trouble need be anticipated, but where such is not the case and where a separate greaser or oiler is provided, it is of the utmost importance to see that it is kept regularly lubricated. The fabric linings are riveted to the flywheel and the pressure disc (C in our sketch) by aluminium rivets. When the linings wear down the rivets may bear on the surface of the driven steel disc E, in which case the clutch will slip, heat up, smell, and eventually be unable to transmit the power and drive the car. When this condition arises new copper and asbestos friction discs should be procured and riveted on with the rivet-heads sunk into recessed holes well below the surface of the linings. There is an adjustment W, as between the pedal T and short lever U, which it will be found necessary to make, when a new pair of linings have been fitted. The pedal will have to be moved further in by screwing back the set-screw X, or it may catch the top of the floorboard at Z before the clutch is fully disengaged. Sometimes failure of the clutch to grip and take up the drive without slip is due to weak springs. This can be remedied simply and cheaply by the procuring and fitting of new and strong ones at a very paltry outlay of money. Stiffness of any of the bearings, shafts, etc., which control the clutch should be avoided. The cross-shaft S particularly (which carries the pedal and the forked releasing lever U) should be well lubricated, as should the sleeve Q, by the greaser shown. The pedal should be quite free in the slot in the floorboard and particular attention should be paid to keeping the ball-thrust washer R well lubricated.

Should such wear take place as would give too much backlash between the ball-thrust collar R and the fork lever U, the thrust collar can be adjusted further towards the forked lever by screwing the abutment collar R2, along sleeve Q, and locking it with the lock collar R3.

CLUTCH-SHAFT.—The steel shaft which conveys power from the clutch assembly to the gearbox of the car.

CLUTCH STOP.—A small braking device fitted to friction clutches which checks the rotation of the revolving member of the clutch when changing up, thus preventing the clutch from spinning.

CLYCEROL.—See *Glycerine.*

COAL GAS.—The well-known illuminating and heating gas obtained by the destructive distillation of coal. Its composition is very variable, but an average sample of purified coal-gas contains approximately the following :—

Hydrogen	48 per cent.
Methane	35 ,, ,,
Carbon monoxide ..	8 ,, ,,
Carbon dioxide ..	1 ,, ,,
Nitrogen	3 ,, ,,
Other hydrocarbons :	—
Ethylene, acetylene, benzene, etc. ..	5 ,, ,,

Coal-gas can be used as a motor fuel, as was amply proved during the Great War. Instead, however, of storing the gas in voluminous bags, as was done during that period, it has been proposed to use steel cylinders of high-tensile strength in which the gas may be strongly compressed.

COBALT.—A steel-grey metal, similar to nickel, which it resembles in many properties. In engineering it is employed as an alloying ingredient of steel to produce high-speed steels, cobalt steels being very hard and tough.

COCK.—A small tap used for controlling the supply of a liquid flowing along a pipe.

In nearly every case cocks consist of a tapered plug, having a hole drilled through it which fits into a correspondingly tapered seating, being held in place by means of a sealing washer and a nut.

COEFFICIENT OF EXPANSION.—A physical property of materials which is of the greatest importance in all engineering design and constructional work

The coefficient of expansion of a material, say a metal is, from a practical standpoint, the increase in length which that material undergoes when it is heated through a temperature of 1oC.

The coefficient of expansion of copper is ·000167, this figure representing the fractional increase in length of a copper bar, rod, or block when it is raised 1°C. in temperature.

Cast-iron has a coefficient of expansion of ·000010 and aluminium an expansion coefficient of 0·000025. These figures show that aluminium is the more expansible metal of the two. Consequently, an aluminium piston is always given a " sloppy " fit within a cylinder.

COG.—A projecting tooth on a wheel.

A wheel having a series of teeth cut on it is known as a *cog-wheel, gear-wheel, spur-wheel* or *pinion.*

COIL.—Term used to denote the induction coil unit of a car which provides the sparking current for the plugs. The induction coil which was originated in 1842 by Masson and Breguet in France was afterwards (in 1851) greatly improved by a Paris instrument-maker called Ruhmkorff, whose name is often still attached to the device.

COLLAR.—A boss or ring formed on a spindle or shaft in order to eliminate end movement. A collar may be made solid with a shaft or it may consist of a separate piece secured to the shaft by keys or bolts.

COLLAR BEARING.—Name given to a form of bearing comprising two projecting rings or " collars " set on each side of the bearing. The collars may be turned solid with the revolving shaft or otherwise attached to it, the bearing just fitting between the collar, and thus allowing of a rotary but not a sideways motion.

A collar bearing gives additional strength to the part.

COLLOID.—A colloid is a substance which forms with a liquid fine suspension therein without being actually dissolved by the liquid. The insoluble substance is then said to be in the colloidal state.

Graphite is a well-known example of the above. By means of special processes it may be obtained in the form of an extremely fine suspension in lubricating oil, and in this form it is used for engine lubrication.

COMBUSTION CHAMBER.—The space above the piston in the cylinder in which the explosive charge is compressed and ignited.

COMMUTATOR.—The revolving part of a dynamo comprising a number of metallic segments to which the armature wires are attached. Current is led from the dynamo by means of carbon blocks or " brushes " which make rubbing contact with the commutator.

The term also refers to that part of a circuit-breaking device which makes contact at regular periods. In this connection the expression is really a misnomer, for here the device does not change or *commute* the direction of the current-flow, but interrupts it instead.

COMPENSATING GEAR. — An old name for *differential gear.*

COMPOUND MAGNET.—A permanent magnet which is composed of two or more individual magnets, as, for example, the compound permanent magnet of a magneto.

COMPRESSION.—The reduction in volume of a mass of material due to externally-applied pressure.

In motoring the term is used to denote the compression of the explosive mixture in the cylinder by the action of the piston. This compression is usually defined in terms of lbs. per square inch, an average engine-compression being about 85 or 90 lbs. per square inch.

COMPRESSION RATIO.—The compression ratio of an engine is expressed in terms of the ratio of the volume of the combustion chamber, plus the capacity of the engine to the volume of the combustion chamber. Thus a 500 c.c. cylinder, of which the combustion chamber volume is 100 c.c. has a ration of 500 + 100 to 100 = 6 to 1.

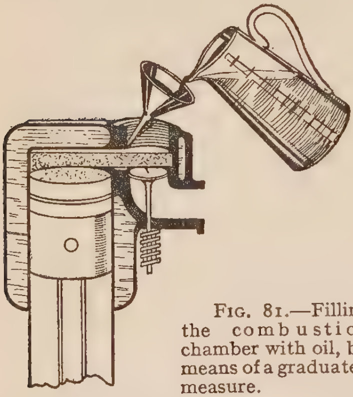


Fig. 81.—Filling the combustion chamber with oil, by means of a graduated measure.

Now the capacity of the engine is usually known, and the only unknown factor is the volume of the combustion chamber, *i.e.*, the volume of the space above the piston when the latter is at the top of its stroke. This can only be measured with a liquid, since it is of an uneven shape, and there are two simple ways of doing it. One is with oil or paraffin and a glass, the other with paraffin and a burette. For brevity's sake we will consider the use of oil only with the measure glass and paraffin with the burette.

Whichever method is adopted the sparking plug or valve cap on a four-stroke or release valve on a two-stroke must first be removed, so that a hole is exposed in the cylinder above the piston. It is impossible to lay down which is best to remove, since engines vary largely in design. The hole through which the oil or paraffin is to be inserted must, however, be at the top of the cylinder; should such a thing not be possible when the engine is vertical, the engine must be leaned either way, or raised at the front or back, until this orifice does come at the top, for if it is not at the top there will be an air-lock in the combustion chamber, and the measurements will be incorrect.

Let us take the easier, cruder way first—that of oil and a measure glass. The glass will probably be marked off in ounces and pints, but these measurements can be converted later. Put, say, about half a pint of oil into the glass, and set the piston at top dead centre. Pour the oil into the combustion chamber until this is just full, and then place the glass on a flat surface, and leave it until the oil has drained down from the sides. The amount of oil which had been used naturally represents the volume of the combustion chamber; it will be shown in ounces, which must be converted into cubic centimetres. If results show that 140 c.c have been used to fill the combustion chamber of a

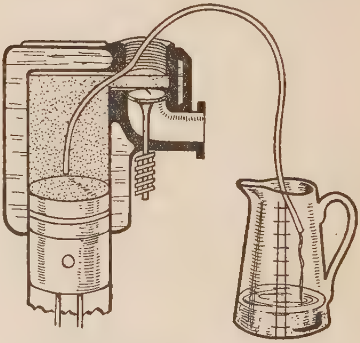


Fig. 82.—Method of extracting the oil from the cylinder.

490 c.c. cylinder, the compression ratio will be $\frac{490+140}{140}=4\cdot5$ to 1

The burette system is easier and more accurate, provided that the piston is not too sloppy a fit in the cylinder, and even in this case is probably more accurate than the oil and glass procedure, provided that it is done when the engine is cold and the rings gummed up with thick oil. The compression ratio can also be measured with a burette when the engine is in the frame, but this is sometimes rather difficult when a measure glass is used.

A burette is, to put it in simple words, a long, thin cylindrical glass measure, usually graduated in cubic centimetres, and with a tap at the lower end. If the orifice in the cylinder is in an awkward position, as it is with most two-strokes or overhead valve four-strokes, a piece of rubber tubing can be fixed to the tap, and led into the cylinder. The volume of the combustion chamber can then be measured in the way already described. A burette can be obtained from any manufacturing chemist for four or five shillings.

It should be remembered that there will be a leakage of paraffin past the piston rings and piston if the paraffin is allowed to stand, and the measuring should therefore be carried out as quickly as possible. It is also advisable to do it two or three times to make sure that no error has occurred. After each measurement the engine should be revolved several times so that all the oil and paraffin may be blown out.

Once the exact compression ratio has been ascertained, the amateur "tuner" knows where he stands. Experiments in the nature of raising or lowering the compression can be carried out, whilst, as a point of interest, the difference in ratios when the engine is clean and when it is carboned up, can be discovered.

There is one purpose for which the measure glass or the burette in unnecessary—that is, for checking the compression ratio after a washer has been removed from, or placed below, the base of the cylinder, provided that the volume of the combustion chamber was previously known. Take the case of a cylinder, with one or more washers below the head. These have purposely been placed there, so that the compression ratio may be raised when required—a practice which is nowadays becoming very common, especially on sports machines. We will say that the owner has previously ascertained that the volume of each combustion chamber is 125 c.c., and that the compression ratio is thus 5 to 1.

When removing a washer, all that he has to do is to measure its thickness and make a simple calculation. The bore and stroke dimensions give a capacity of 500 c.c., and it therefore follows that each millimetre of the stroke gives a capacity of $\frac{500\text{ c.c.}}{88}$

If, then, he removes washers to the total thickness of 4 mm., say, he is reducing the volume of his combustion chamber by $\frac{500}{88}=4$c.c.

=23 c.c. approximately. The new compression ratio will thus be $\frac{500+200}{102}=5\cdot9$ to 1.

Usually the raising of the compression ratio connotes the use of a special fuel so that full advantage may be taken of the high compression thus obtained. It is as well to point out that little advantage is gained by raising the compression ratio on ordinary fuels.

COMPRESSION, LOSS OF—When an engine commences to lose power, and gear changing has to be indulged in more frequently on hills, one can rightly suspect loss of compression. Bad pulling is also caused by carbonisation, but in this case pinking plus the mileage covered since the last decarbonisation, will indicate the reason for the defect.

There are several ways of testing compression, one of the most usual being to turn the engine by hand noting the resistance of each cylinder. The test is made whilst the engine is hot, so that oil resistance is negligible, and is naturally of most value if one is used to the " feel " of the engine's normal compression. This pre-supposes the use of the handle occasionally for starting purposes, which incidentally is well worth while, for not only does it spare the battery, but ensures that an engine is in good tune by starting at the comparatively slow speed obtained by hand cranking as against the electric starter.

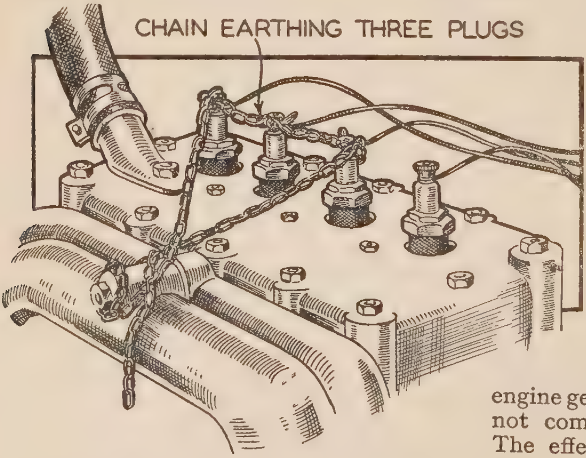


FIG. 83.—Each cylinder can be tested in turn by short-circuiting the plugs of the other cylinders as shown.

Testing Compression.—Gauges are obtainable which screw in the sparking plug holes, and many garages also employ a gauge which records the actual explosion pressure—an important point. If these are not available a simple device which has often been used successfully, can be made from a length of light gauge chain, attached to two wooden handles. For testing an engine, one end of the chain is hooked on to a convenient point of the engine, and the other portion laid on all the plug terminals except the cylinder it is desired to test. (*See* Fig. 83.) Thus the engine is being driven by one cylinder only and if the throttle is opened fairly quickly, the ability of the engine to pick up will be shown. Each cylinder is dealt with similarly, and any that are losing compression will be detected at once, either by refusing to run on the one cylinder, or by its inability to accelerate when the throttle is opened.

Tappet Clearances.—Assuming that one cylinder is at fault, the first point to check is the tappet clearances, and quite possibly the exhaust valve will be found to possess none. Unfortunately many owners in their quest for silence, allow insufficient clearance for the tappets, consequently when the engine gets hot the valve does not completely seat itself. The effect is that a portion of the exploding mixture is blown past the seating, and its heat quickly warps the valve and perhaps the seating too. In the early stages one may be able to effect a cure by grinding in the valve, but unless a new seating begins to show itself immediately, a new valve should be used. Average tappet clearances are ·004 inch. for the exhaust, and ·003 inch. for the inlet valves.

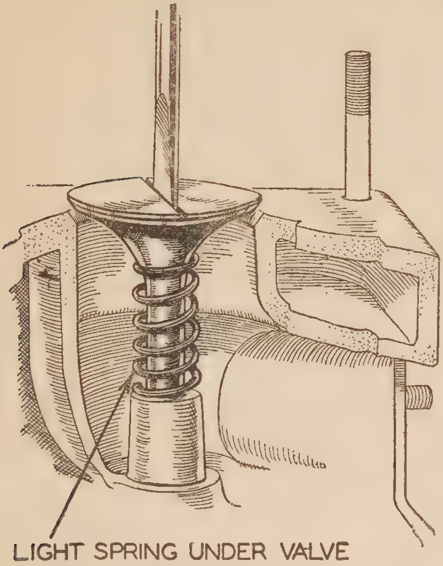


Fig. 84.—A light spring under the valve to assist grinding-in.

Valve Grinding.—A badly carboned engine will cause a loss of compression. The reason is that particles of carbon get imbedded between the valve and its seat, so preventing a gas-tight closing with the result just mentioned. One can now see that decarbonising and valve grinding go hand in hand, and that the two jobs should be done at the same time whenever possible. Many motorists have various misconceptions in regard to valve grinding, believing that rotating the valve and using a lot of paste gives the best results. This is quite wrong, and the points to watch are :

(1) Never rotate the valve continuously in one direction, as this will only tend to form grooves. The valve should be oscillated to and fro, and lifted from time to time ; a light spring under the head of the valve as shown in Fig. 84 will be found useful.

(2) A minimum of grinding paste is desirable, commencing with coarse and finishing with fine.

(3) A wide seating is not necessary, and one should aim at a clean, smooth ring.

Although the ill-effects of lack of tappet clearance have been emphasised, too great an amount is also detrimental. In this case the opening of the valve is delayed, restricting the amount of mixture entering the cylinder, and preventing the free dis-

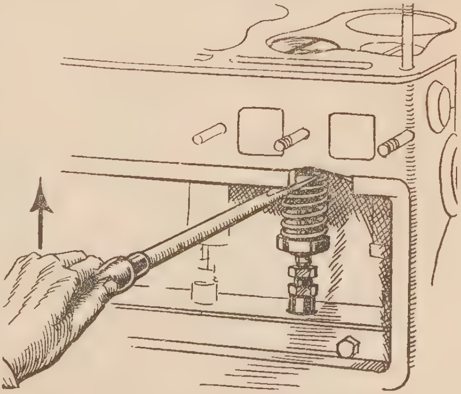


Fig. 85.—Detecting a weak spring by inserting a screwdriver in the coils.

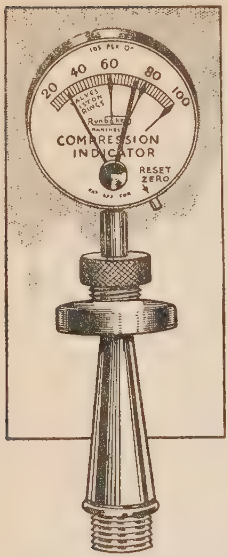


Fig. 86.—This compression tester is a useful device which can be screwed into the cylinder in place of a sparking plug.

charge of the exhaust. The combined result is an increase in back pressure and a lowering of the compression.

Weak Valve Springs.— Another cause of power loss is weak valve springs and generally the exhaust is the culprit. A simple method of testing, without removing the spring, is to increase the spring compression by inserting a screwdriver as shown in Fig. 85. If the engine speed increases, a new spring is indicated.

The remaining reason for lack of compression is piston-ring wear, and the method of overcoming this defect is fully explained under its appropriate heading. It might be added that this trouble can usually be detected before dismantling, firstly by eliminating the causes already mentioned, and secondly by listening for any hissing noises from the crankcase, when the engine is turned by hand.

COMPRESSION STROKE.—The upward stroke of the piston which drives the explosive mixture before it and compresses it in the combustion chamber.

COMPRESSION TAP.—A small tap controlling an opening communicating directly to the interior of the cylinder. It enables pressure to be released and also provides a means of directly injecting liquid fuel into the cylinder.

CONDENSER.—Term usually applied in motoring matters to the electrical condenser which is included in the magneto or coil assembly and whose function it is to prevent or retard sparking across the contact-breaker points.

CONDENSITE.—A form of Bakelite material employed in the making of electrical insulating fittings, instruments, parts, etc.

See *Bakelite.*

CONDUCTOR.—Electrical term signifying any medium which affords a path for an electric current. The majority of metals are good conductors. Water is also an electrical conductor. This fact should be borne in mind when tracing electrical faults due to short-circuits in the car's electrical system.

CONE.—A piece of metal having a tapering surface, as, for instance, the cone of a frictional clutch.

A disc of hardened steel which has been provided with a concave or other suitable surface to form a race or channel for the steel balls of a ball-bearing.

CONE CLUTCH.—A simple type of frictional clutch in which the flywheel of the engine usually makes frictional contact with a metal cone faced with leather, asbestos, or composition fabric. An inner cone, similarly faced, also makes engagement by means of a strong spring.

CONNECTING ROD.—A light metal bar connecting the underside of the piston to the crankshaft. It is provided with bearings at each end and is usually made in light but strong steel. (See also *Pistons, Connecting Rods, and Bearings.*)

CONSERVATION OF ENERGY.—The great principle which states that energy cannot be destroyed. It may be changed, but it is never annihilated. When energy seems to disappear, it merely undergoes conversion to another form of energy, as, for example, when the frictional energy of a rubbing bearing appears in the form of heat energy which raises the temperature of the bearing.

The principle of the Conservation of Energy was first stated by James Prescott Joule (1818-1889). It constitutes one of the most fundamental principles of the Universe, for, upon its operation, all physical and mechanical processes depend.

CONSTANTAN.—A resistance metal containing 60 per cent of copper and approximately 40 per cent of nickel. It is used in the making of resistance coils in electrical measuring instruments, etc.

CONTACT BREAKER.—A mechanical device for rapidly interrupting the low-tension circuit of the ignition system.

CONTACT SPARK.—A spark which occurs between the points of the magneto or coil contact-breaker. If the latter is correctly adjusted, there should be little or no contact spark.

CONTINUOUS CURRENT.—See *Direct Current.*

CONTOUR.—The outline of a body. The word is more usually applied in connection with motoring to denote the up-and-down nature of roads, their degree of acclivity, etc.

Referring to map-reading, " contours," or " contour-lines," are lines which are drawn on maps and charts through all points having the same height above sea-level.

CONVECTION.—The transference of heat from one part of a liquid (or a gas) to another by means of circulatory currents (" convection " currents) set up in the liquid by virtue of the difference in density between its hotter and cooler portions.

It is the operation of this principle which enables one of the water-cooling systems of car engines to function.

See *Thermo-syphon circulation.*

COOLING-FINS.—See *Fins.*

COOLING-JACKET.—Name applied to the jacket enclosing the engine cylinders through which the cooling water flows in its journey to and from the car radiator.

COOLING SYSTEM.—Term usually applied to the system whereby water is continuously circulated around the engine cylinders in order to prevent them from attaining an excessively high temperature.

See *Pump circulation, Thermo-syphon circulation.*

As explained on the following page, cooling systems are of two types—that depending on thermo-syphonic flow, in which advantage is taken of the fact that hot water tends to rise and thus induces a flow in the water circulation system, and that in which a mechanical pump (either of the worm or thrower type), positively forces water round the water-jacket, cylinder-head and radiator.

The cooling system is the most trouble-free part of the mechanism of the car and because of that the most neglected. The chief troubles (detailed in following pages), are air lock, formation of lime crust in radiator tubes, and leaks. Most of these troubles can be avoided by periodic attention to the various parts, and the instructions which follow show how this may be done efficiently.

COOLING SYSTEMS EXPLAINED.—The petrol engine being a heat engine (burning its fuel in the cylinder), it would get exceedingly hot, making it impossible for it to continue to work, if means were not adopted to regulate its temperature. The cooling system is not intended to keep the engine as cool as possible but to prevent it getting too hot. The engine is not too hot if the water does not boil. A temperature found to exactly suit the petrol engine, when it gives its full thermal efficiency, is just below boiling-point.

Thermo Syphon System.—The cooling water would very quickly be boiled away in steam if provision were not made for cooling it; for this purpose it is kept constantly circulating through the cylinder-jackets and a radiator, placed in front of the car, so that it gets a flow of air through it. This lowers the temperature of the water previously heated in the cylinder-jacket and allows it to return to the jacket cooled. As hot water rises and cold water falls, we have a means of natural circulation ready at hand. It is called the thermo-syphonic system, and is diagrammatically shown in Fig. 87. A is the water-jacket surrounding the four cylinders 1, 2, 3, 4. B is the radiator, which has air-tubes through which the air flows as the car travels forwards. The direction of the air is shown by the parallel arrows. As the water gets hot in the cylinder-jacket (A) it rises up the pipe (C) into the radiator (B). Here it gets cool, falls to the bottom, and flows up the pipe (D) to take the place of the hot water flowing out at the top. So long as this circulation continues and the water does not boil, the engine will be kept at the right temperature.

Correct Level Necessary.—If the water in the radiator and jacket system falls below the line X-Y there will be no further circulation, but water in the jackets will boil away and steam will issue from the radiator vent, so that it is necessary to ensure that the level never drops below the outlet of the pipe C into the radiator head. There is an overflow pipe so that in filling one can fill right up to the top of the filling orifice. This is the simplest form of cooling system. It has nothing to get out of order, and so long as there are no leaks, it will work efficiently without attention other than filling up. But the level of the water must be maintained.

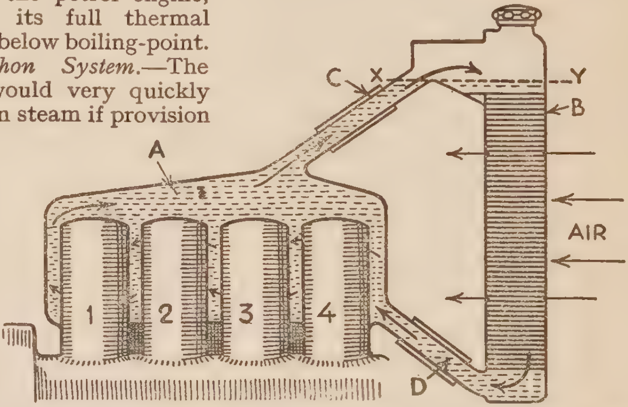
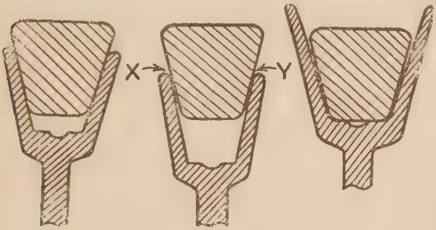


FIG. 87.—Diagram showing the circulation of water through the cooling system.

Fan Assistance.—To ensure a good flow of air through the radiator a fan is often fitted behind it.

Generally it is driven by a belt from a pulley on the crankshaft. This belt should not be too tight, and it should fit the V groove in the engine and fan pulleys correctly. Figs. 88, 89 and 90 show the fitting of the belt in the pulley groove. In Fig. 88 the belt is in correct position and shape. The sides of the belt bed closely to the sides of the pulley groove, in line with it, but the belt does not reach the bottom. Such a belt will drive without slipping and without being tight. It will not "bottom" in the pulley groove. In the arrangement shown in Fig. 89 the belt is too wide and not the right angle, and it beds on the top edges of the pulley groove. It will not drive the fan unless it is very tight, and the pulley flanges will cut into the belt at X, Y and eventually destroy it. In Fig. 90 the belt is too small, too narrow, and it is bedding down on the bottom of the pulley groove. This belt will slip and drive the fan at too low a speed. A slipping fan-belt may quickly cause boiling of the cooling water and overheating of the engine. Various methods have been devised for adjusting the fan-belt. Some fan-belts also drive the dynamo and a convenient method is the mounting of the fan and pulley combined at the forward end of the dynamo armature spindle, in which case the dynamo is mounted eccentrically, so as to allow of adjusting the tension, or it is mounted on a sliding spigot for the same purpose. Where this arrangement of mounting the fan on the dynamo spindle is adopted, it is very necessary to avoid too much tightening of the fan-belt, in order to prevent too much strain on the ball-bearings of the armature spindle.



FIGS. 88, 89 and 90.—Showing correct and incorrect methods of fitting the fan belt; FIG. 88 (*left*) is the correct method.

Fan and Impeller.—Many engines have an impeller pump built into the detachable water-jacket head. The arrangement is shown in Fig. 91. The aluminium water impeller projects inside the detachable-head water-jacket, and the same spindle carries the belt pulley (by which it is driven) and the air fan. A stuffing box (A) is fitted inside, and the spindle runs in ball- or roller-bearings. The whole can be removed, for packing or adjusting the stuffing-box or bearing, by unscrewing the flange B. The impeller will screw out sideways when the flange is released. Sometimes the stuffing-box is outside, and is thus accessible without removing the pump. The impeller pump will allow water to pass it by thermo-syphonic circulation should the belt break.

In bigger engines a centrifugal pump is often fitted and driven by the same shaft as drives the dynamo, at the side of the engine. In all these pumps the important part is the stuffing-box. This is an adjustable, water-tight joint around the pump spindle. How the pump should be packed is shown at Fig. 92. The spindle A passes through a gland B, which is taper recessed at its end and screws into the pump body. Between the end of the recess in which the gland screws and the recessed end of the gland, packing is compressed around the pump-spindle, when the gland B is screwed

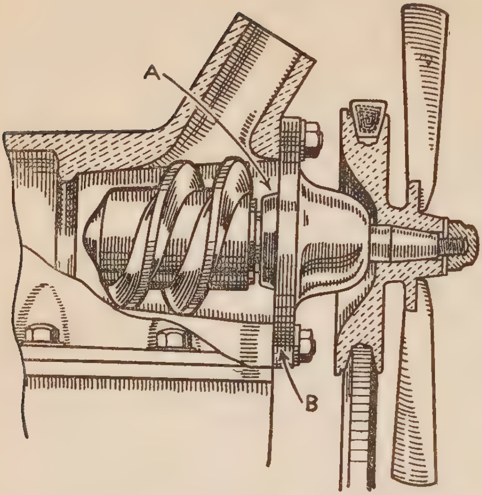


Fig. 91.—This section through a cylinder head shows how an impeller pump works in conjunction with the fan.

up. The packing should be of cotton or hemp, well soaked in tallow and placed round the pump-spindle and pushed into the recess while the gland is pulled back. Then the screwing up of the gland will tighten the packing around the pump-spindle and make a water-tight joint.

When freezing takes place, the water pump is generally frozen, and in the case of a mechanically-driven pump (not belt-driven) it is wise to warm the pump to ensure thawing of the ice: otherwise when the engine is started the pump drive will be sheared. Overheating, and probably a piston seizure, is very likely to occur under such circumstances. In cold weather use a non-freezing solution in the radiator and water-jacket, or let the water out each night. This last method encourages lime deposit, which prevents radiation of the water, and the anti-freezing solution, kept in during the winter, is the best, safest, and most convenient method of preventing cracking of the engine jacket through frost, which would necessitate an expensive repair.

Radiator Repairs.—The majority of radiator leakages commence through vibration. Therefore it is not wise to neglect attention to any item that can possibly contribute towards the damage of the radiator. Apart from the question of leakage, periodic attention should be given to ensure that the water is able to circulate freely throughout the cooling system.

Elements of the Radiator.—A radiator can be likened to two small rectangular tanks, placed one above the other and, say, 20 inches apart. These tanks are connected together by a series of wide, flat, corrugated tubes having a cross-section of about 3 inches by $\frac{1}{16}$ inch. When the engine is running the water heated by the cylinders rises into the top tank. It then passes down through the tubes in comparatively

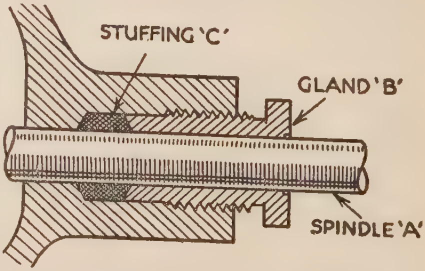


Fig. 92.—It is essential to pack the gland in order to prevent water leakage.

small streams, and by reason of the outsides of the tubes presenting a large area to the air, the water reaches the bottom tank in a much cooler condition, as already explained.

In any system in which water is heated there is always the unwanted production of scale and sediment, this being true of a water-cooling system on the car. Lime in the form of scale or sediment, or both, together with rust particles, and maybe oil, are constantly passing through the radiator in large or small quantities, according to the age of the car or the attention bestowed upon it.

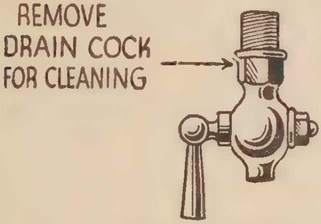


Fig. 93.—After draining the Radiator, remove the drain cock and flush the radiator by means of a hosepipe.

Thus it will be seen the somewhat restricted water space in the tubes, or, for that matter, between the tubes of a honeycomb type of radiator, would not require very large pieces of foreign matter to lodge in them to form a complete blockage, or at least reduce the rate of flow of the water through the tubes. Where such a condition exists the efficiency of the radiator is naturally very much reduced.

Cleaning.—A tendency to boiling without apparent reason, or an indication by the calorimeter that the engine is running unduly hot, may be regarded as a sign that the cooling system needs attention. Where the present owner knows the history of the car, what is done as regards the following will be dependent upon his knowledge as to whether it has been recently done, but where the car is a recently-purchased " second-hand " one, the mind will be set at rest on this point.

Partly drain the radiator and fill up with a solution of caustic soda, made by dissolving the contents of a 1-lb. tin of caustic soda in 2 gallons of hot water. Keep this off your hands and off the paintwork, if you value them both. Run the engine for about 30 minutes and drain off the soda water. Let the hose pipe run into the filler neck for a few minutes, with the drain-plug out, or where a cock is fitted, with it removed (Fig. 93). After replacing remove the bottom hose-coupling and flush out again, closing the radiator outlet part of the time to divert the whole of the flow of water through the cylinder-jackets. It is then quite a good practice to flush the radiator out with water at fairly frequent intervals.

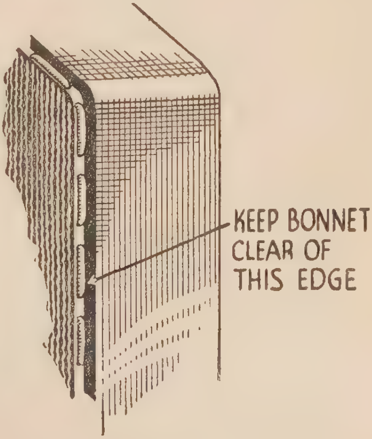


Fig. 94.—To avoid wear, see that the bonnet fits correctly.

Vibration.—As previously stated, vibration is the main indirect cause of leakage. The actual leakage may come about by breakdown of the metal from crystallisation, or from chafing arising out of vibration.

First examine the radiator mountings and see that the fixing bolts are tight. Rubber packings, fitted to protect the radiator from shock, should be resilient ; if hard, they are perished and require renewing.

Radiator stays should be tight and doing their job properly. Where the top bonnet hinge-rod is intended to form the stay, see that it is nutted up or otherwise securely fixed.

Another point to note is that the bonnet shuts down correctly : it should seat down on to the damper-tape clear of the edge of the radiator, (*see* Fig. 94). Observance of this point is particularly important with radiators of the non-shell type, as usually along this edge there is a soldered joint, which if allowed to become cut away or worn by chafing, is very difficult to repair satisfactorily.

It is quite a simple matter to adjust the radiator-stay so that the bonnet, when seated, clears this edge by an equal amount all round.

For this reason, also, keep an eye on the bonnet fasteners, and never let them become in such a condition that they will not clamp the bonnet down securely.

If the bonnet pulls down hard at the bottom without contacting with the damper strip on the radiator, the possibility is that the strip requires renewing ; where it is in order a thicker one might be fitted to take up the space. Failing this, the radiator would require raising a little.

Repairing Leakages.—Nothing is more annoying than a leaky radiator, and while certain compounds are obtainable to put into the radiator, some are not to be recommended, owing to their liability of reducing the effectiveness of the cooling.

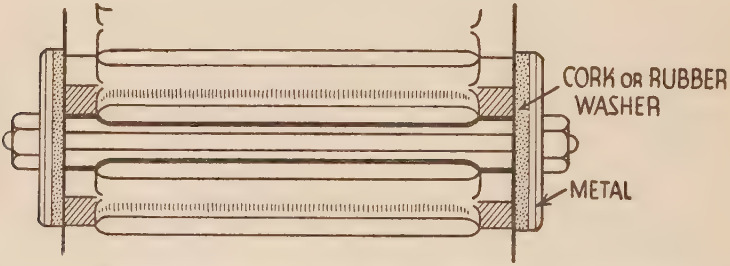


FIG. 95.—Temporary method of repairing a honeycomb type of radiator.

A method of making a temporary repair to stop a leak in a honeycomb type radiator is shown in Fig. 95. This will serve either where the tube is cracked inside or where the leak is on the face of the radiator. Obtain a small bolt long enough to pass through the section, two large metal washers with small holes, and two cork or rubber washers. A metal washer is placed on the bolt followed by one of the soft ones. The bolt is then passed through the defective tube and the remaining soft washer, metal washer and nut put on and tightened.

A lot can be done in the way of

radiator repairing by those who have a mechanical turn of mind and can solder. There are, however, certain jobs that should never be attempted. Leakages that occur at the junction of a tube and the reservoir are, unless of a minute character and at the extreme ends of the front or back, best severely left alone. In the course of manufacture these tubes are soldered from the inside, that is before the assembly of the reservoirs. Thus such repairs call for skilled attention.

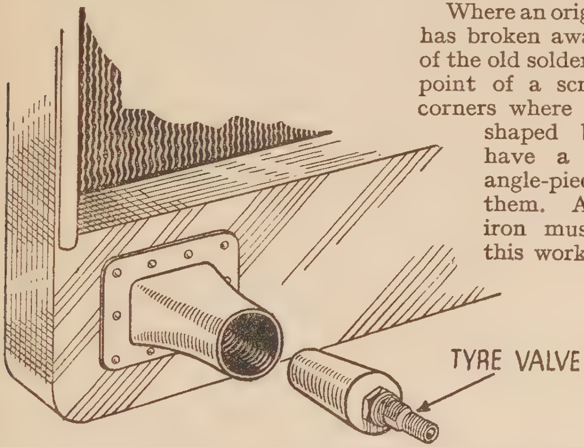


FIG. 96.—Method of testing the radiator by air pressure.

Very little can be done in the way of soldering without removing the radiator. When it is off for this purpose it is advisable to carry out a test in order to trace the source of the leak with absolute certainty, and also to ascertain the extent of the crack.

To carry out such a test it is necessary to plug up the overflow pipe with a rubber cork. The top and bottom outlet pipes must be treated in a like manner, one of them having a hole bored through into which a tyre-valve is passed, as illustrated in Fig. 96. It will also be necessary to fit a thick, soft leather washer into the radiator cap so that it seats hard on to the filler neck when screwed on.

A few pounds of air pressure is pumped in and the suspected leaky portion of the radiator immersed in a bath of water to detect the source of air bubbles.

Where an originally soldered seam has broken away, remove as much of the old solder as possible with the point of a scraper. Cracks along corners where the metal has been shaped by bending, should have a light-gauge brass angle-piece sweated over them. A heavy soldering-iron must be employed for this work, owing to the rapid chilling effect of such a large mass. Before refitting the radiator the efficiency of the repair can be seen by re-testing.

COPPER.—A well-known reddish metal, which being (next to silver), the best-known conductor of electricity, is universally employed for that purpose. For this use, however, the metal must be in a high state of purity, traces of contaminating substances within it considerably reducing its conductivity.

Fortunately, copper is very ductile. Hence it can readily be drawn out into wire. It has a tensile strength not very much less than that of iron.

CORDS.—Used in connection with pneumatic tyres, this term refers to stout strands of cotton or other material which have been impregnated with rubber. They enter into the construction of many types of outer cover.

COTTER, COTTER-PIN.—A tapered pin or wedge of round or square cross-section which, by fitting into a slot, is used for holding two parts together.

The cotter-pins of engine valves are small metal pieces which, by passing through slots in the bases of valve stems, keep the valve-spring washers in position.

COUNTERBORE. — A surface which is formed concentrically around a drilled hole generally for the purpose of providing a recess to receive a spring or other washer.

The name given to the tool which is used for this purpose.

COUNTERSHAFT.—An intermediate rotating shaft which is driven from the primary or engine-shaft and which transmits motion to the rear-wheels of the car.

COUNTERSINKING.—Term referring to the making of a conical hole in the surface of a metal or wooden article so that the head of a screw which is afterwards inserted into it will be flush with or below the surface of the object.

Countersinking is generally carried out in order to provide a neat finish to an article or for the purpose of eliminating projecting screw-heads.

COUPE.—A term which designates the all-enclosed body of a car seating, usually, two individuals.

Coupé is a French word which originally referred to the front part of a French stage-coach.

COUPLING.—Name applied to the various means of connecting together two parts—generally two shafts in line with each other—so that the revolutions of the one are transmitted to the other.

COVER.—A term which is usually applied to the outer cover, or casing of a pneumatic tyre.

CRACKING.—A technical term which denotes the operation of heating heavy oils and petroleum residues so that they break-up in lighter oils, these being distilled over and collected. By this process a considerable proportion of heavy petroleum residues are annually transformed into light fuels.

The process is more scientifically known as one of "destructive distillation."

CRANK.—A lever or arm formed on a shaft, its object being to convert reciprocating motion into rotary motion.

CRANKCASE.—The metal casing or cover which surrounds and encloses the crankshaft and its assembly.

CRANK CHAMBER. — See *Crankcase.*

CRANKPIN.—The short part of the crankshaft which receives the downward thrust from the piston.

CRANKSHAFT.—The main revolving shaft of the engine which converts the up-and-down movements of the pistons into rotary motion.

Most crankshafts are made from solid forgings and are left soft. After the forging has been made it is put aside for several months to allow all stresses set up in the forging process to manifest themselves. A forging will warp as much as a quarter-of-an-inch, and it will hence be realised that were machining carried out within a few days of the forging being made, the shaft would rapidly go out of alignment and bind up in its bearings. Even after the seasoning process the shaft is not completely machined but a roughing cut is taken and the shaft is then laid aside to allow the internal stresses (released by the removal of the outer scale in the first machining operation), to take effect. During this second seasoning further warping takes place, and after a further seasoning period the shaft is then finally machined.

CRANKSHAFT BEARINGS, FITTING.—In the earlier days of motoring, crankshaft bearings were almost universally made from phosphor bronze. At the comparatively low speeds that the engines developed their full power this material was fairly satisfactory, as the heat generated was controllable to a large extent by the system of lubrication then employed. When, however, the lubrication failed and the oil film between the surface of the bearing and the journal broke down, the resultant seizure more often than not played havoc with the engine generally. The least to be expected from such a happening was for the surface of the journal to be torn or otherwise spoiled. This led to the general adoption of the practice of lining the bearing with white metal which, on account of its low-melting point, would run under the influence of the heat generated by the friction between the surface when running in a dry condition. This did to a large extent preserve the shaft from damage, but as the bearings were lined with metal about $\frac{1}{8}$ inch thick, the tendency was for it to spread rather rapidly, and when a big-end did run, the hammering that the bearing bolts received was terrific, and ruptured bolts were no uncommon thing.

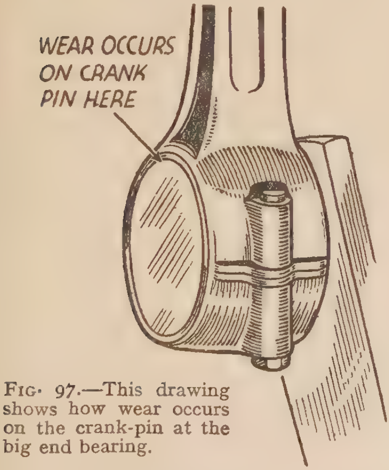


FIG. 97.—This drawing shows how wear occurs on the crank-pin at the big end bearing.

In modern engines the thickness of this lining is cut down as much as possible, being in many big-ends no more than $\frac{1}{32}$ inch.

Wear on the Crank-pin.—The parts of a crankshaft that receive the most wear are the crank-pins. These parts tend to wear oval. At every revolution of the engine the downward travel of the piston and connecting rod is arrested by the crank-pin and the direction reversed. Therefore the greatest pressures are exerted on the pin by the bearing at the top and bottom of the stroke. Extra friction is caused at those points by the thinning of the oil film with the result that the pin in time wears smaller in one direction (*see* Fig. 97).

When it becomes necessary to take up wear in or renew the bearings, the examination of the crankshaft is a matter of primary importance, as it is, of course, impossible to refit a bearing properly to an oval shaft.

Carefully examine the crank-pins and main journals for wear and scores. Where new main bearings are to be fitted, and providing that the journals are otherwise correct, remove any ridges worn by annular oil grooves in the bearings with a very fine file, afterwards polishing with fine emery cloth. Crank-pins may be tried for roundness with a small pair of outside spring callipers, although a micrometer is a much more reliable tool to use, as it allows more exact measurements to be taken.

Methods of Truing Worn Pins.—There are several methods by which worn pins may be trued up again to a round condition. If the amount by which the pin is out of truth is only small, say a thousandth of an inch, the truing can be carried out as shown in Fig. 98. The shaft is securely clamped to the bench or held in a vice, and the high places removed by lapping with a belt charged with grinding paste. Previous measurements will have revealed the highest part of the diameter and it is against this that the belt must be pulled. A narrow belt about ¾ inch wide and approximately 3 ft. long, is smeared in the centre on the smooth side for a length of 6 inches with coarse carborundum grinding paste. The belt is then pulled backwards and forwards around the pin, working it gradually from side to side at the same time. Repeat the process on the opposite side of the pin, maintaining the same pressure and working for an equal period in order that the lapping is carried out evenly. Hold the belt ends wide enough apart to allow the portion of the belt passing round the pin to make contact with an area equal to no more than a quarter of the circumference. Clean the work off from time to time and check, to see what progress is being made.

Measurements should be taken in three or four places in a line along the pin, and again at 90 degrees to the first measurement. When these readings agree, intermediate ones should be taken at 45 degrees each way, high spots being removed as before. When the pin is reasonably round the micrometer is set and used as a fixed gauge, taking care that it passes over the shaft in every position with the same "feel." Being satisfied that the pin is round, clean off with paraffin and well polish with fine emery tape. Although it may sound slow and complicated, actually it is not so, and if the lapping is done methodically a good job will result. Take care that no grinding paste or emery dust is allowed to remain in the oil-holes, and for this reason thoroughly flush out the oil ways from one end of the shaft with a syringe.

Making a Lead Lap.—Similar to the foregoing method is that in which a lead lap is employed. A square block of lead is cast 1 inch wider across the flats than the diameter of the crank-pin, the depth being shallower by ½ inch than the width between the crank webs.

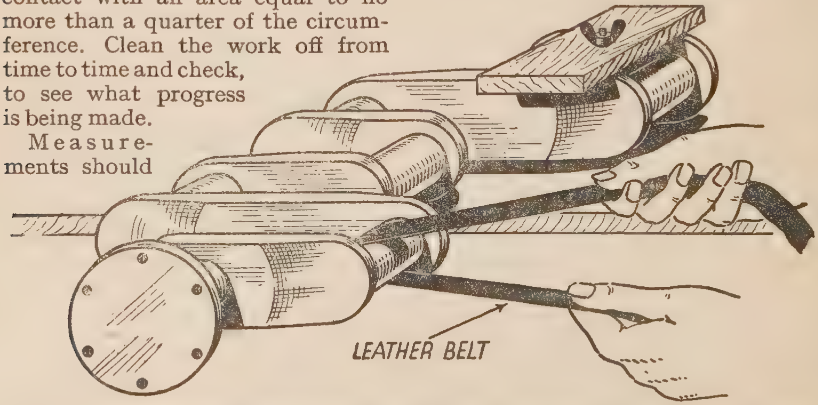


Fig. 98.—Showing how the crank-pin can be trued up when it is only slightly worn.

Bore a hole through the centre of the block the same diameter as the crank-pin and radius the edges of the hole to suit the fillets on the shaft. Drill a ⅜ inch clearance hole lengthwise through the block on either side of the centre hole.

Split the block in halves across the holes. Make two steel plates ⅜ inch thick and the same size as the ends, drilled to suit the centres of the ⅜ inch clearance holes in the block. A round handle is fitted to the centre of one plate and the blocks bolted together with a plate at top and bottom, the assembly being like a connecting rod. After lightly fitting the lap on to the crank-pin, it is fed with grinding paste and oil and rocked backwards and forwards by means of the handle, working along the pin to cover the whole length. It is only necessary to tighten the bolts slightly to make the lap a friction fit. The rate of cutting will not be increased by adjusting the bolts so that the lap is hard to move, the only effect will be to tear the surface of the lead. After a short while the lap becomes thoroughly impregnated with abrasive, but more can be added as the cutting action becomes noticeably less.

As with valve grinding, this operation must proceed cautiously, and the formation of rings can be prevented providing the lap is not completely rotated. The shaft will afterwards need polishing in the manner before mentioned.

Crankshaft Tools.—A special tool is made for truing crankshafts. Briefly it consists of a split ring hinged or bolted together. Adjustable flat steadies project into the centre of the ring, as also does a wide flat steel cutter. In use the halves of the ring are opened, passed over the crank-pin, and closed. The steadies are then adjusted until they bear on the pin, allowing the ring to be rotated without shake by means of a stiff tommy-bar, when the cutter is brought to bear against the shaft. This shaves the surface of the shaft and the fillets are cleaned up by moving the ring along in both directions. Oil is used as a lubricant and to prevent the metal from tearing.

The successful use of these tools depends to a large extent upon the cutter, which must be maintained in good condition. Any slight serration on the cutter edge is reproduced on the work, so that the cutter must be honed up to a perfect finish.

Before an oval pin can be dealt with, it is necessary to make it reasonably round by filing. This should be done with a fine file for a width at least equal to that of the cutter. When the centre of the pin has been cut true the sides and fillets can be dealt with by the cutter.

CRANK-WEBS.—The portions of a crankshaft which unite the crankpin to the crankshaft.

CREOSOTE, CREOSOTE OIL.—A coal-tar distillate of brownish-black oily nature, well-known as a preservative, and used at times as a heavy fuel for certain types of internal combustion engines.

From the Greek, *Kreas*, flesh; *sotor*, a saviour—so named on account of its flesh-preserving properties.

CROWN.—See *Piston crown.*

CRYPTO GEAR.—Name sometimes given to a form of epicyclic or planetary gearing consisting of a large cogwheel driving two or more smaller pinions, these engaging with a wheel having teeth on its inner circumference.

CUBIC CENTIMETRE.—A Metric System measure of volume or capacity, employed for many scientific measurements and for denoting the cylinder capacities of car engines, especially smaller ones.

A cubic centimetre (c.c.) represents the volume of a cube whose sides are 1 centimetre long.

For scientific uses the cubic-centimetre is now being displaced by the *millilitre,* which is a thousandth of a litre.

CUFF VALVE.—A type of engine valve working on a principle similar to that of the ordinary poppet-valve. It comprises, essentially, two concentric metal sleeves, cylinders, or " cuffs," the inner cuff acting as an inlet valve and the outer one serving as an exhaust valve.

By means of a special mechanism, these cuffs operate in due sequence, thus controlling the admission and exit of gases into and from the cylinder.

CUP AND BALL JOINT.—See *Ball joint.*

CURRENT.—The flow of electricity through a conductor.

CUSHION TYRE.—An old type of tyre comprising a cover of thick, hard rubber secured to the wheel-rim and between which existed a small air space in which air was confined at ordinary atmospheric pressure.

CUT-IN.—Name given to an electro-magnetic device which automatically switches over the dynamo output circuit to the accumulator as soon as the dynamo, having attained a certain speed, begins to generate an " effective " current.

Usually a cut-in of this type is designed to act only after the dynamo voltage is considerably higher than the accumulator voltage.

CUT-OUT.—A device, usually operating on an electro-magnetic principle, which serves automatically to open and close a battery-charging or lighting circuit.

Also, a device which gives a perfectly free escape for the exhaust gases of an engine.

CYCLE.—A sequence of operations of a recurring nature. Applied in connection with the internal-combustion engine to the regular sequence of operations taking place within the cylinder, as, for instance, the " four-stroke cycle."

CYLINDER.—A circular metal chamber in which the cycle of operations necessary for the development of power from the explosion or rapid combustion of fuel vapour mixed with air is carried out.

D

DAMPING.—Term used in motoring technics to describe the action of springs in reducing or discouraging the transmission of vibrations from one member to another.

The leaf-springs of the car's suspension system, for instance, *damp-out* a large proportion of the road shocks and vibrations suffered by the wheels of the car.

DASHBOARD.—The older name for the instrument board of a car. Originally the term signified a board set in front of a carriage to keep off the dashes or splashes of dirt and mud.

D.C.—See *Direct Current.*

D.C.C.—An abbreviation used in electrical wiring to denote double cotton-covered wire.

See *D.S.C.*

" DEAD POINTS."—Term used to denote the points of " dead top-centre " and " dead bottom-centre " of a piston within a cylinder at which points it momentarily stops and performs no work.

DECANE.—Chemical formula: CssH_1°. A colourless hydrocarbon liquid. Bolling-point, 173°C. Specific gravity, 9·730. Occurs in petrol fuels.

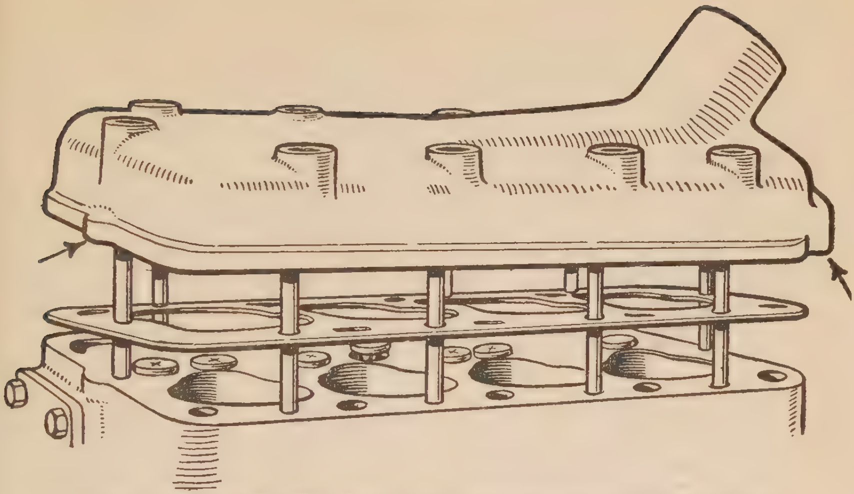


FIG. 99.—Cylinder head partly lifted, arrows showing projections on casting to enable head to be levered up.

DECARBONISING.—Name given to the mechanical operation of removing carbon from the interior of the combustion chamber, the piston assembly, and other parts.

Periodical decarbonising of the engine is necessary on account of the choking effect of the accumulated carbon on the interior, economy, and mechanism of the engine.

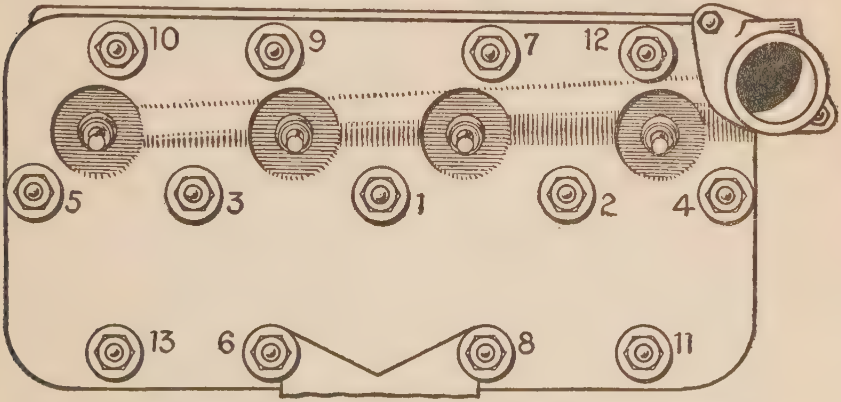


FIG. 100.—Order of tightening Cylinder-head Nuts to secure uniformity of pressure and thus prevent leakage.

DECARBONISING AND VALVE GRINDING.—Every engine requires decarbonising at fairly regular intervals. A new engine should be decarbonised after the first 2,000 miles, and every 10,000 miles afterwards. A new engine, too, should have the crank-case and gearbox drained after the first 500 miles, to carry away the residue formed during the running-in period. Do not flush the sump with paraffin unless it is removed from the car.

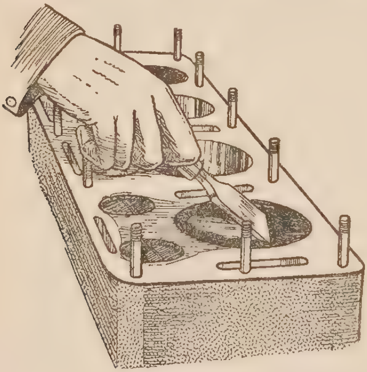


FIG. 101.—Scraping carbon from the piston heads.

It should be mentioned here that carbon is a poor conductor of heat, and its presence in any great quantity on the piston and inside of the cylinder-head causes overheating, "pinking" (a metallic, high-pitched noise when the engine is running), pre-ignition (the carbon becomes red-hot and fires the gas in the cylinder in advance of the plug), and loss of power. If the engine pinks it is a sign that it needs decarbonising.

The process of decarbonisation is simple, and one which every owner-driver can undertake with a few simple tools, such as a scraper, long screw-driver, and the tool-kit supplied.

Preparation for Decarbonising.—A little preparation is necessary so that the work may be carried out expeditiously and to ensure that the parts which it will be necessary to remove are correctly replaced. Those tackling such a job for the first time should have at hand a large tin of paraffin, into which some of the smaller parts can be dropped, a number of small boxes so that nuts and bolts can be kept in their correct order and plenty of clean rags. The hands should also receive attention, otherwise it may be difficult to get them really clean. A good dodge is to fill the nail crevices with soap by clawing the nails across a piece of it. The rest of the hands, too, should be rubbed with a piece of dry soap; this will make the removal of the dirt fairly easy afterwards.

Some old sacking or sheets of brown paper should be available, so that the oil, carbon, and dirt do not spoil the floor of the garage.

Having made these preparations, the engine should be run until it is nicely warm, as joints are broken more easily and nuts are easy to remove when warm; and in cold weather it is certainly more comfortable to handle warm parts. While the engine is warming up, time can be saved by removing the bonnet and any other accessories which may be in the way. As screws, nuts, etc., are removed they should be marked in some certain way, so that each nut goes back on to the nut or stud from which it was removed. When the engine is warm, drain the radiator (the tap or drain plug will be found at the bottom of the radiator), unfasten the clips securing the water pipes to the head and the cylinder-block, and then withdraw the pipes from the cylinder-head and base. Next remove the sparking-plugs.

Removing the Cylinder-Head.—We now arrive at a stage when it is necessary to remove the cylinder-head. Engines with valves operating from a camshaft in the crankcase are simple to decarbonise, as the parts to be removed do not in any way affect the timing of the engine. When an overhead camshaft is fitted, however, the camshaft drive must be disconnected, necessitating re-timing the engine after assembly. If you are uncertain regarding this operation, it is doubly necessary to mark every part. Most engines have the parts marked to make re-timing an easy matter. When the camshaft is driven from bevel or helical gearing, the teeth are usually marked in some way. If they are not, mark them before removing the head and the drive, by turning the starting-handle until No. 1 piston is at the top of its stroke, and then mark the teeth in engagement. At the same time note the position of the ignition distributor arm in order to get the ignition timing correctly reset upon assembly. It is wise to consult the instruction manual issued with the car before actually removing the head.

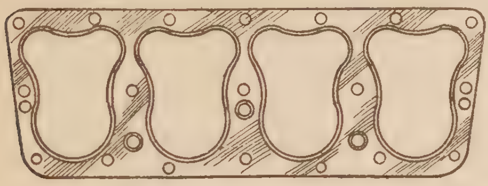


FIG. 102.—A typical Cylinder-head gasket.

It will be found that the head is always held in position by a series of nuts screwed on to the head of the studs projecting from the cylinder-block and passing through the cylinder-head casting. It is of considerable importance, especially with shallow heads, that these nuts should be gradually removed by giving each in sequence half a turn at a time until they are all quite loose. If this is not done there is danger of producing local strain in the casting leading to its permanent distortion and preventing the attainment of a gas-tight joint when the head is reassembled. Slacken off the centre row of studs first.

Once the cylinder-head retaining nuts and any other components likely to interfere with the removal of the head have been detached, the head may be withdrawn from the studs. It will be necessary to break the joint between the cylinder-head and the cylinder-block. This joint is made by a copper asbestos washer or gasket to which a jointing compound has been

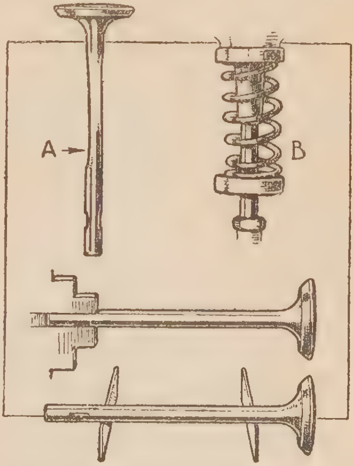


FIG. 103—A Spring distorted, as at B, gives rise to a Worn Stem, as shown by A. The lower sketches show the valve held in a lathe chuck for re-truing, and the method of testing the stems for truth and straightness.

applied. A typical example of such a gasket is shown in Fig. 102. Great care should be taken not to damage this gasket in any way by inserting wedge-shape tools to remove it. There is usually some point of leverage which can be taken advantage of to prise the head off. If this cannot be done, insert a couple of hook-shaped rods with rough handles bent on the other ends into the plug-hole and lift the head with a direct upward pull. Another method of breaking the joint is to give the engine a few turns with the starting-handle, when the motion of the pistons will break the joint. Yet another method is to give the cylinder-head a few blows all round its outer edge with a piece of hard wood or a lead hammer. Once the joint is broken, lift off the head and gasket, and place it on a bench. Put the gasket in a safe place where it will not be bent or distorted in any way.

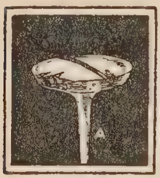


Fig. 104.—The appearance of a burnt-out valve—often due to a faulty valve-spring or incorrect tappet adjustment.

Removing the Carbon.—The removal of the cylinder-head will expose to view the tops of the pistons, and each of these should be successively brought to the top of the stroke while the carbon is being carefully scraped off with a blunt screwdriver or a special scraper (Fig. 101). Whilst one piston is being operated on, rags should be stuffed into the cylinder bores so that the carbon removed does not fall into them. Two pistons, of course, will be at the top of the stroke at a time, and both of these may be cleared of carbon before operating on another pair. The water passages should also be stuffed with rag. When all pistons have been attended to in this way proceed to scrape away the carbon deposits adhering to those portions of the cylinder-block which form part of the combustion chamber, taking great care not to damage the valves or valve-settings. Finally, wipe off all traces of carbon with a cloth which has been damped with paraffin. Do not use emery cloth, for particles may become embedded in the aluminium and may subsequently work loose when the engine is running, and spoil the cylinder.

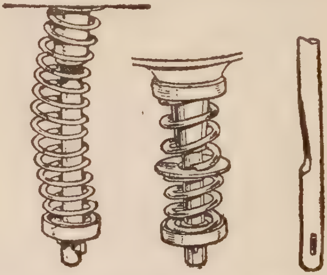


Fig. 105.—Further effects of faulty Valve Springs. The centre diagram shows how a broken spring may be temporarily repaired.

Removing Carbon from the Cylinder-Head.—Turn it upside down and scrape off the carbon, not forgetting the interior of the plug opening, finally cleaning the surfaces with a rag damped in paraffin as before.

The Gasket.—Now prepare the gasket for replacement. Clean it carefully, supporting it on a flat board during the process. Remove all traces of the old jointing compound together with any traces of carbon. If not satisfied that the gasket may be used again, obtain a new one, for it is better to do this than to run the risk of having to remove the head again owing to a leaky joint.

Attending to the Valves.—Before replacing the head it is well to consider whether the valves are in need of attention and regrinding. It should always be concluded, when decarbonising, that the valves are also in need of attention. This will necessitate removing the valves completely. To do this, use may be made of a special valve-spring lifter, which clips over the spring, compressing it up the valve guide. One method of doing this is to get an assistant to exert, by means of a long screwdriver and a block of wood placed over the valve head, sufficient leverage to prevent the valve moving, whilst you compress the spring with tyre levers or a screwdriver and remove the cotters, taking care that they do not slip down through the oil-spray hole into the crank-case. Next, lever the valve stem through its washer so that a grip may be obtained on its head to withdraw it. The valves and seats can now be inspected.

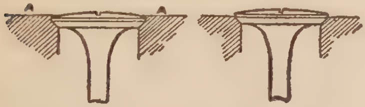


FIG. 106.—Diagram showing at A a masked or pocketed Valve, and on the right a correctly-seated Valve.

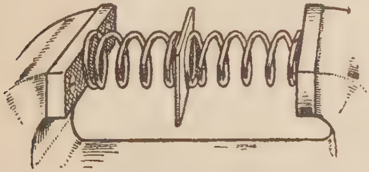


FIG. 107.—Valve Springs may be tested for strength in this manner. The weaker spring will be compressed more than the other.

Inspecting the Valve.—Carefully inspect the edges of the valves and the seating to see whether they are pitted, and examine the stem to see whether they are straight or worn. The springs themselves are sometimes distorted. A distorted spring usually gives rise to wear on one side of the valve stem only (Figs. 103, 104, and 105). The springs themselves may be tested for relative strength by screwing two of them with a plate of metal between in the jaws of a vice. By screwing up the vice the spring which is weaker will compress more readily than the stronger. If the springs are of equal strength the distance from plate to each jaw of the vice will be the same (*see* Fig. 107).

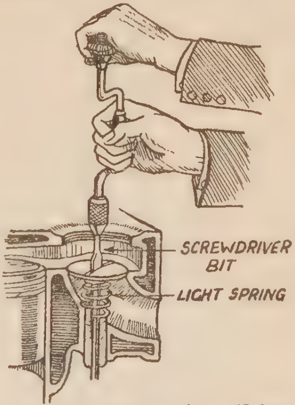


FIG. 108.—Grinding in a Valve.

Grinding-in Valves.—Valves should be ground in by using any of the well-known valve-grinding pastes. These are obtainable in two-compartment tins, one containing coarse paste, the other fine or finishing paste. If the engine is comparatively new it will not be necessary to use the coarse paste, the purpose of which is to rectify badly-fitted valve seatings. If the valves themselves are badly pitted they should be sent back to the makers for re-facing, or perhaps a local agent would undertake the work for you. Such valve pittings should not be removed by grinding the valve into its seating. Such a process would inevitably result in the valve becoming pocketed or masked. In this condition the gases would not be able to enter or leave the cylinder effectively (*see* Fig. 106). You can only get a true valve seat by using a valve which is in itself true. To grind in the valves, lightly smear the seating with the paste and then place the valve in position, rotating it a part of a revolution in either direction. Frequently lift the valve and partially turn it, continuing this operation until the face is evenly ground. Do not attempt to grind in a badly pitted valve, for excessive valve grinding wears away the seating and causes the valve to become pocketed with consequent loss of power. After grinding in, be very careful to wipe away all traces of the grinding material, both in the valve and in the cylinder (*see* Fig. 106). Continue this grinding operation until a nice even and clear surface is shown on the valve and its seating. Scale can be removed by means of a piece of emery cloth cut as shown in Fig. 109 and slipped over the valve stem. This operation would, of course, precede that of valve grinding. A very light spring placed under the valve and fastened to the copper groove will lift it off its seat when it is desired to remove its position and greatly facilitate the valve-grinding operations. Remove all traces of the emery paste with paraffin and a rag, taking particular care that none of this runs into the cylinder (Fig. 108).

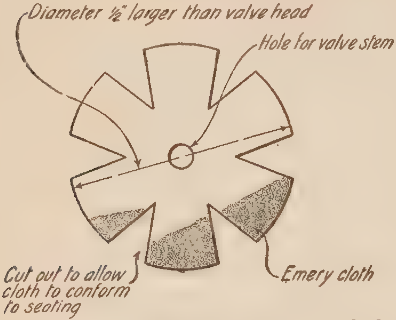

Diameter ½" larger than valve head
Hole for valve stem
Cut out to allow cloth to conform to seating
Emery cloth

FIG. 109.—A piece of fine emery cloth, cut as shown, is useful for removing scale from valve seatings ; slip it over the Valve Stem. Rotate the valve with a screwdriver, and the scale will be removed from the seating.

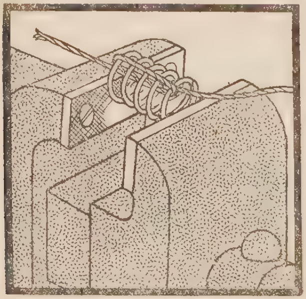


FIG. 110.—Tie the spring with string after compressing in a vice.

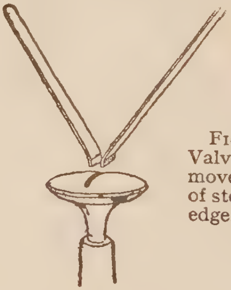


FIG. 111.—Sticky Valves may be removed by two pieces of steel filed to a thin edge.

Re-assembling the Valve.—To re-assemble the valve, first compress the spring between the jaws of a vice and tie it with strong string, or a piece of wire (Fig. 110). It may then be slipped over the valve guide, the washer and cotters placed into position and the string then cut, or if the valve compressing tool referred to is available this may be used for valve replacement.

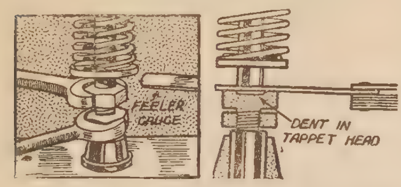


FIG. 112.—(*Left*) Adjusting a Roller Type Tappet ; (*right*), a dent worn in the Tappet Head may give a false adjustment.

Adjusting the Tappets.—After re-grinding the valves it is obvious that the tappet clearances will need adjustment. The exhaust valves should have a tappet clearance of ·006 of an inch, and the inlet valve tappet ·004 of an inch. Do not use visiting cards, as is so often recommended for this purpose, but a special feeler gauge which can be purchased for a few pence (*see* Figs. 112 and 113).

Removing the Stud.—If it is necessary to remove one of the cylinder-heads holding down studs, two nuts should be used in the manner shown in Fig. 114, jamming these together by two spanners, and unscrewing the stud by applying the spanner to the bottom nut. The stud may be re-inserted or tightened by using the spanner on the top nut.

Re-assembling.—We have now arrived at the stage when the cylinder head may be replaced. A jointing compound will be needed for the gaskets. A number of proprietary compounds are available, but boiled linseed oil, goldsize, shellac, thick varnish, are all satisfactory. The surface of the cylinder block, both sides of the gaskets, and the cylinder-head surface should all be thinly and evenly coated with this jointing. See that there are no lumps in it, for these would prevent the formation of a water and gas-tight joint. Slip the gasket over the studs and press it down into place by means of a box spanner pushed over the stud. Then drop the head on and tap it down all over with a block of wood. Next, spin the nuts down finger-tight and proceed to tighten up the head as in Figs. 99 and 100, on p. 83. Take care, in the case of an overhead camshaft engine, to see that it is replaced with its timing marks in their correct relative positions, according to the maker's instructions, or in accordance with your own proportions. Proceed to tighten the nuts in the order shown in Fig. 100. Do not lock each nut down at once; give each nut a half-turn and continue in the order indicated until the head is locked firmly down. This will cause a certain amount of the jointing to exude. Do not remove this ; continue to replace components such as water-pipes, carburettor, etc., and

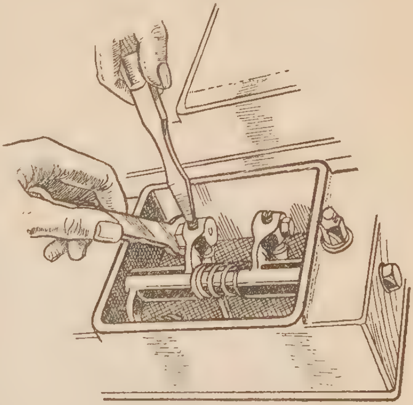


FIG. 113.—Adjusting the Tappets in the rocker box.

start up the engine, allowing it to run for about ten minutes to get it warm. Then give the nuts on the cylinder head a final tightening.

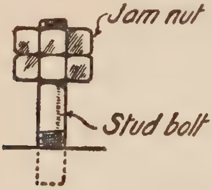


FIG. 114.—Method of inserting and removing Studs. Two nuts are jammed together. In removing the stud, apply the spanner to the bottom nut, and *vice versa*.

DEGREE.—The 360th part of a circle. The term is applied in this respect to certain engine measurements.

For degrees of heat, see *Centigrade* and *Fahrenheit.*

DENSIMETER.—See *Hydrometer.*

DESAXE SETTING. — A term referring to the arrangement of an engine cylinder over its crank shaft, the axis of the cylinder being offset from (or non-coincident with) the axis of the crankshaft, this type of construction being designed to reduce the pressure between the piston and the cylinder walls.

DESTRUCTIVE DISTILLATION.—See *Cracking.*

DETACHABLE HEAD.—Term referring to a modern development of car engines by which the upper portion of the cylinders is made detachable, thus providing easy access for cleaning.

DETACHABLE RIM. — Name given to a class of road-wheel rims which are made detachable in order that the tyre may be removed from the wheel with the rim of the latter attached to it, thus making for easy substitution of a fresh rim and tyre.

There are many types of detachable rims available nowadays.

DETACHABLE WHEEL.—Name used to describe a readily removable road-wheel of a car, the wheel generally being slipped over a hub fixed to the end of the axle.

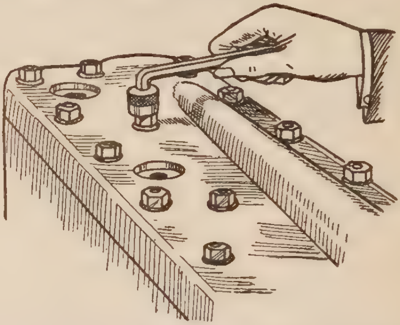


FIG. 115.—When replacing the Cylinder Heads tighten the nuts in the centre first.

The detachable wheel is a development of the detachable rim.

DETONATION.—An engine knocking phenomenon, usually occurring in engines working on light fuels, which is due to a portion of the mixture becoming heated up by its compression and spontaneously exploding just in front of the wave of burning gas, which has been ignited normally at the plug points.

Slight detonation is usually known as " pinking," which see.

DEVIL.—A device for preventing a stationary car from running backwards down a steep hill—a sprag.

DEWANDRE BRAKE.—A car-braking system in which the engine suction is employed to operate the road-wheel brakes. In this power-braking system, the maximum braking effect is brought into play when the car is travelling at the lowest speeds because, under these conditions, the available engine suction is at its maximum. Hence, with the Dewandre braking-system, excessive braking cannot be applied at high road-speeds, thus averting the danger of skidding. (See also *Vacuum Brakes.*)

DIAGONAL.—A line drawn between two opposite angles of a four- or many-sided figure.

DIAMETER.—The diameter of a circle is the length of a straight line passing through the centre of the circle and terminated at opposite ends by the circumference. It is, of course, equal to twice the radius of the circle.

DICKEY.—A name used to denote the extra seat fitted at the back of a two-seater car and which usually folds down when not in use.

DIE.—A device used to cut threads on the exterior of a shaft or other piece of work. In its simplest form a die comprises a piece of hard metal provided with an inner thread which is firmly secured in a *Die-stock* or handle. See *Tap.*

DIESEL ENGINE.—A type of internal-combustion engine first devised in 1892 by Dr. Rudolf Diesel (1857-1913).

In the Diesel engine a charge of air is drawn into the cylinder by the piston and then highly compressed. The compression effected is so high that the air becomes hot enough to ignite a charge of fuel which is injected into the cylinder-head just at the end of the compression stroke. Ignition follows, and the piston is driven downwards again by the expansion of the burning mixture. It will be observed, therefore, that the Diesel engine obviates the necessity of using any external source of ignition such as an electric spark.

Diesel engines are made to operate on the two-stroke principle as well as on the four-stroke cycle.

Engines of the Diesel type will work on heavy fuels. For many years they have been used exclusively as stationary engines, but they are now being applied to heavy road-vehicles.

DIE STOCK.—See *Die.*

DIFFERENTIAL GEAR.—A system of toothed wheels which transmit power from a main shaft to two shafts at right angles to it despite the fact that these latter may have to revolve independently at different speeds. Fitted to the back-axle of a car, the differential gear contrives to enable one of the rear wheels to travel faster than the other as is necessary, for example, when the vehicle is turning a corner.

The invention of the differential, at least as concerned its application to double-driven road vehicles (that is to say, vehicles having the power equally applied to the two front or the two rear wheels), is due to a Coventry mechanic named James Starley, to whose memory a monument (having a replica of the balance gear let into the marble in lead), now stands on Coventry Green.

He applied his invention to the Salvo Quadricycle—a four-wheeled pedal driven vehicle—so that the power was applied to each wheel in automatic proportion according to whether the machine was being driven straight or in a circle, as when turning a corner.

This simple fact will be clearer to the reader if he visualises a gate swinging on a hinge. It is obvious that the hinged end will move through a small circle whilst the outer end moves through a greater circle in the same time and therefore at greater speed.

The differential comes into play even if the car veers from one side of the road to the other, or if one tyre is slightly deflated and therefore of smaller diameter than its mating wheel.

Action of the Differential.—In order that one driving wheel of the car may rotate faster than the other, as is necessary in turning corners, and yet both wheels continue to be driven by the engine, a device is introduced which "differentiates" between the speed of inside and outside wheels; it is called the differential gear and is explained here.

The principle of the bevel differential gear (because it uses bevel toothed wheels) can be demonstrated by the model Fig. 116. Two shafts A and B are in line with each other (they have a common axis), and can rotate independently of each other and in either direction, being connected by a small shaft which fits in the end of each and carries the lever F. At the ends of the shafts A and B is a fork, and when C is pulled A is rotated and when D is pulled B is rotated. On lever F is a cross-pin E which is pivoted around F and whose ends fit inside the forks C and D. If we hold A and pull F towards us, fork C will hold back the end of the pin E, but F will draw pin E forward and it will turn on its bearing on F, and the other end of the pin will pull D forward and so partially rotate shaft B. If we hold B, and free A, the same action will occur in the case of shaft A which will be pulled forward by the end of the pin engaged with fork C. If both shafts —A and B— are free, and we pull F, the shafts will be pulled equally, E acting as a pull-bar.

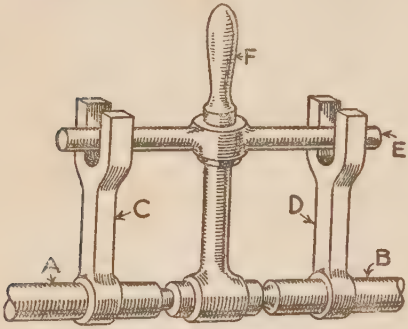


FIG. 116.—Rough model to demonstrate the principle of the differential.

This differential motion can only take place through a small arc of a circle described by F, since the pin E would jam if C and D were pushed too far away from each other. But if we replace forks C and D by bevel wheels fixed to shafts A and B respectively, and replace the cross-pin E by a bevel pinion rotable on lever F, we can keep on pulling lever F round the shafts indefinitely. If we hold A, which is fixed to bevel wheel C, and pull F round, the pinion E being geared to C will roll round it. But the teeth of E away from C will be travelling at twice the speed relative to F, and so will push wheel D round and leave shaft A stationary. If we hold shaft B and pull F the same action will be taking place, but wheel C will travel

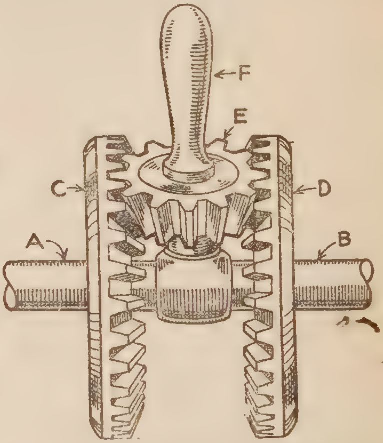


FIG. 117.—Development of the model shown by FIG. 116.

faster than F. If both axles, A and B, are free and we pull F, both axles will turn round at the same speed and in the same direction as F and there will be no relative motion between the bevel wheels A and B and the pinion E. If we had our car road-wheels at the ends of shaft A and B, and our engine rotated F, the car would be driven by both wheels equally. But if one of the car wheels was retarded or made to travel more slowly than the other (as in rounding a curve) then the differential action would come into play. Thus, if the road-wheel on shaft B was retarded (due to its being inside the curve) the differential action would begin to take place. Pinion E would turn round lever F and drive shaft A (by bevel-wheel C) at a speed faster than the speed of shaft B. The differential gear would cause F to continue to drive both wheels round but at different speeds.

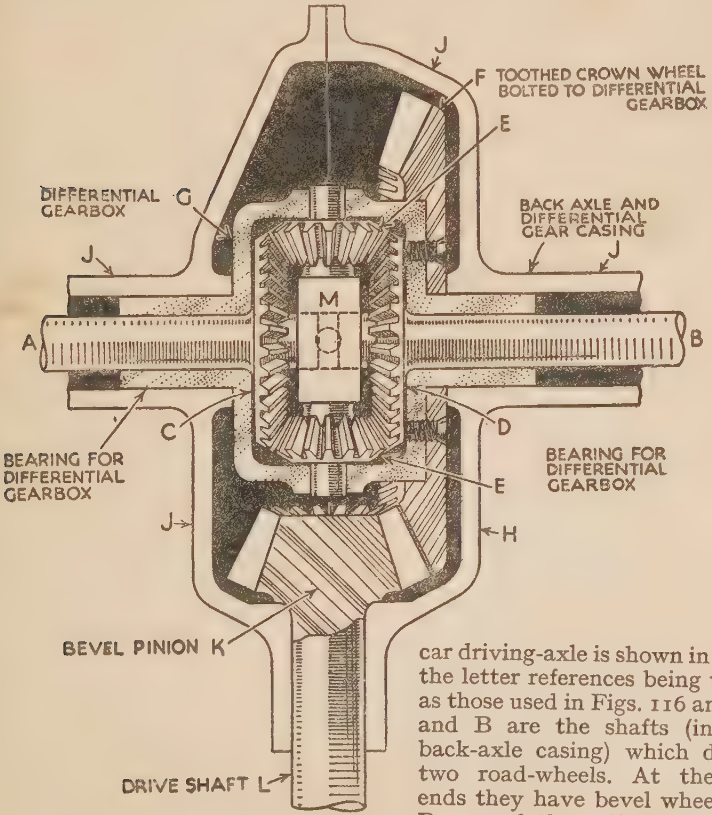

J
F TOOTHED CROWN WHEEL BOLTED TO DIFFERENTIAL GEARBOX
E
DIFFERENTIAL GEARBOX G
BACK AXLE AND DIFFERENTIAL GEAR CASING
J
J
J
M
A
B
C
D
BEARING FOR DIFFERENTIAL GEARBOX
BEARING FOR DIFFERENTIAL GEARBOX
E
J
H
BEVEL PINION K
DRIVE SHAFT L

Fig. 118.—Section through a bevel differential gear.

Crown and Bevel Wheels.—How this principle is applied to the motor car driving-axle is shown in Fig. 118, the letter references being the same as those used in Figs. 116 and 117. A and B are the shafts (inside the back-axle casing) which drive the two road-wheels. At their inner ends they have bevel wheels C and D around them (free to rotate on bearings on shafts A and B), an inside casing J is a box, or drum G, inside which are mounted bevel pinions E, E gearing with the bevel wheels at the ends of the driving-shafts A and B. This box is free to rotate inside the back-axle casing and the toothed bevel crown-wheel F is riveted to it. Rotating F is the same as moving levers F in the two previous diagrams, because it carries round the box G, the bevel pinions moving with it. Crown-wheel F is itself driven by the bevel-drive pinion K on the end of the drive-shaft L which is driven by the engine.

It will be seen that if the road-wheel shaft A is stopped or retarded, shaft B and its road-wheel will be accelerated. So that whatever curve or corner the vehicle is caused to traverse, by the act of steering, the differential gear will still divide up the drive from the engine between the two road-wheels, although at different speeds.

But when the car is steered on a perfectly straight course the box G is driven round complete, but with no relative motion taking place between the bevel-wheels, pinions E, E simply pulling round wheels C and D and their road-wheels, together as one solid mass and in the same direction.

" DIM "-FILAMENT.—The filament of a dual-filament headlamp-bulb which, being connected to a small resistance coil in the base of the bulb, or being made of thicker wire than the normal incandescent filament glows but dimly when the normal lighting current is supplied to it.

DIPPER.—Name given to a metal projection formed upon the big ends of many engines whereby a quantity of oil in the crank-chamber is scooped up and splashed around the engine bearings at each revolution of the crankshaft.

DIPSTICK.—Name given to a narrow metal rod which, being dipped into a petrol- or oil-tank, is used to ascertain the depth of fluid therein. The same device is employed for determining the depth oil in gear-boxes, etc.

DIRECT CURRENT.—An electrical current which flows continuously in one direction along a conductor. Abbreviation : *D.C.*

Direct current is necessary for charging a battery, and also for actuating a coil.

DIRECTION-INDICATOR.—A name now customarily given to a small, movable arm fitted to the car in a position near the driver's seat and so arranged that it can project outwards from either side of the car, thus being visible from the rear and affording an indication to an approaching or overtaking car of the driver's intentions.

Driving indicators are often electrically equipped with Neon glow-tubes in order to render them more prominent.

DISC-CLUTCH.—See *Multiple-disc clutch.*

DISCHARGE.—Electrical term signifying the passage of electrical energy (usually in the form of a spark) between two points. An electrical discharge, for instance, takes place between the electrodes of the sparking-plug.

The term is also commonly applied to denote the rate of flow of electricity from a battery or accumulator.

DISH.—Term applied to a curvature given to a wheel so that its centre or hub is bent outwards from the vertical plane.

DISTANCE ROD.—Name given to denote any rod the purpose of which is to maintain the same relative distance between parts, no matter what position they may occupy as a result of their movement.

Applied to cars, the distance-rod is a long rod or bar joining the two stub axles which carry the front road-wheels. It is sometimes called a "Tie rod."

DISTRIBUTION GEAR.—Another name for the timing-gear of an engine.

See *Timing-gear.*

DISTRIBUTOR.—A device for conveying electrical current to various centres in rotation.

The revolving part of a magneto which sends current to the plugs in ordered sequence.

DOG.—A technical term which denotes a forging or casting which has two or more arms formed into a horseshoe or other curved shape.

DOUBLE - NOTE HORN. — An electric type of horn which is designed to give a sharp note or a note of lessened intensity under the control of the driver.

DOUBLE - POLE SYSTEM. — Term usually referring to the electric-wiring system of a car in which a two-wire circuit is used throughout, there being no "return" through the frame or metal work of the car.

The double-pole system of car electrical equipment, although costlier, is more reliable than the single-pole system.

See *Single-pole system.*

DRAIN-COCK.—A tap provided for the purpose of draining-off liquids from a tank or reservoir. A drain-cock is sometimes provided at the lowest part of the engine crankcase for the purpose of drawing off waste oil.

DRAIN-PLUG.—See *Drain-cock.*

DRILL.—A small steel shaft, suitably pointed and grooved, which when rotated under firm pressure forms a hole in the material to which it is applied.

The drills used in automobile construction and engineering are of many different sizes and patterns.

DRIVING DOG.—An old form of clutch in which a series of steel jaws or teeth on the one member engage in corresponding recesses in the opposite member.

DRIVING MIRROR.—A small circular or rectangular mirror attached to the front of a car near the driver's seat in order that the driver may be able to see the state of the road behind.

Driving mirrors are compulsory articles on all cars in this country.

DRIVING PLATES.—Name commonly attached to the metal discs or "plates" of a clutch which are mounted directly on the engine shaft and thus serve to convey the power to the opposite or "driven" plates of the clutch.

DRYING-UP.—Term employed to denote the gradual departure of oil or other lubricant from a bearing owing to the non-provision of a further supply. Eventually, such a bearing will "run dry."

The term also applies to a similar state of affairs taking place between the piston and the cylinder.

DRY-SUMP LUBRICATION.—A system of engine lubrication in which two oil pumps are used. One of the pumps feed oil from a reservoir around the engine-bearings under pressure, the other pump removing surplus oil from the sump and returning it to the oil reservoir.

The system is complicated, but it has the advantage of enabling the engine to be fed continually with a supply of cool, clean oil. The dry-sump system of lubrication is often applied to high-power cars.

D.S.C.—An abbreviation used in electrical wiring to denote double silk-covered wire.

DURALUMIN.—Name given to a class of aluminium alloys containing aluminium, copper, magnesium and manganese in varying proportions. Used, at times, for car construction and for the production of high-grade castings.

Alloys of the Duralumin class were first devised during the war for the production of airship frames and girders.

DUST CAP.—Usually the name is given to a metal cap which is screwed over the end of a wheel hub in order to prevent the entry of dirt.

DUTCH OIL. — See *Ethylene Dichloride.*

DYNAMIC LOAD.—Term used to describe the load on a shaft whose centre of gravity does not coincide with its axis of rotation, as, for example, the crank webs on the main engine shaft of a car. Dynamic loads on a shaft tend to set up excessive vibration and to cause much increased pressure on bearings which, in consequence, have to be made very heavy to stand up to the continual strain.

DYNAMO.—A machine which converts mechanical into electrical energy. In its first form, the dynamo is the invention of Michael Faraday, the great electrician.

DYNAMOMETER.—An instrument for measuring the brake-horse-power of an engine.

DYNAMOTOR.—Name given to a type of combined dynamo and electric motor which can serve the purpose of car dynamo and self-starting motor.

DYNE.—The scientific unit of force. A dyne is the amount of force which when applied to an object having a mass of one gram will produce in it an acceleration of one centimetre per second at every second.

E

" E " ALLOY.—A copper-berullium alloy of American origin containing 2·25 per cent of beryllium. Owing to its strength and its high resistance to heat and wear, it has been employed in America for the construction of valve guides in high-class engines.

EARLY IGNITION.—See *Advanced Ignition.*

EARTH : EARTHING. — Terms used to denote the connection to the earth or to some substitute for it by a wire carrying a current whereby the electrical circuit is completed.

In car electrical equipment the engine or the chassis itself is always employed for an earth connection, this simplifying much of the wiring.

EBONITE.—See *Vulcanite.*

ECCENTRIC.—A modification of the crank, comprising a means whereby the rotary motion of a shaft may be converted into an up-and-down or reciprocating motion.

Usually, an eccentric consists of a circular piece of metal mounted out of its centre upon a shaft. In automobile engineering, the eccentric mechanism has been employed for the construction of lubricator feed-systems.

EDDY CURRENTS.—Stray electrical currents which circulate within the iron frame or core of an electro-magnetic apparatus, being excited therein by magnetic induction. They represent loss of electrical energy and in the design of a good electro-magnetic instrument, such as a magneto, they are carefully guarded against by a special laminated construction of the inner core which hinders their free circulation.

EFFICIENCY. — See *Thermal Efficiency, Mechanical Efficiency, Useful Efficiency.*

ELASTIC LIMIT.—A physical and engineering term used to denote the maximum extent to which a body may be stretched and then return to its former size and shape after the stretching forces have been removed from it.

ELECTRIC HORN.—Name given to a class of sound-producing instruments which operate in consequence of the rapid vibration of a metal diaphragm by means of a small electro-magnet or serrated cam.

Electric horns, on account of their convenience of use, are, perhaps, the most popular sound-warning devices of the present day.

ELECTRODE.—The terminal of an electrical conductor.

In car practice the term is more commonly restricted to the battery terminals (" battery electrodes "), and the points of the sparking plug (" plug electrodes ") across which the spark passes.

ELECTROLYTE.—The liquid within a battery or accumulator which carries the current between the two electrodes. For example, dilute sulphuric acid constitutes the electrolyte in most accumulators used on cars.

ELECTRO-MOTIVE FORCE.—An expression used to denote the pressure or voltage of an electrical current. In practice it is the difference in electrical potential between any two points in a circuit. Abbreviation: *E.M.F.* (See *Volt.*)

ELLIPTIC SPRING.—A type of car spring which comprises two half-elliptic springs attached together at their ends.

EMERY.—A naturally occurring mixture of corundum (impure aluminium oxide) and iron oxide. It is extremely hard, and, in powder form, or as " emery cloth " it is much used in every garage and repair-shop for grinding and smoothing valves and other metal objects and surfaces.

E.M.F.—See *Electro-motive Force.*

EN BLOC.—Term referring to the casting of the engine cylinders in a single block or unit, such cylinders being said to be " en bloc."

This construction makes for cheapness of production, for greater compactness of design and for increased strength of the engine assembly.

ENERGY.—Energy is best defined as the ability to do work. It is an intangible entity, indestructible but capable of great change.

See *Kinetic Energy, Potential Energy.*

ENGINE.—A prime mover. The name given to the mechanism of a car in which the motive power is developed.

From the Latin, *Ingenium*, skilful.

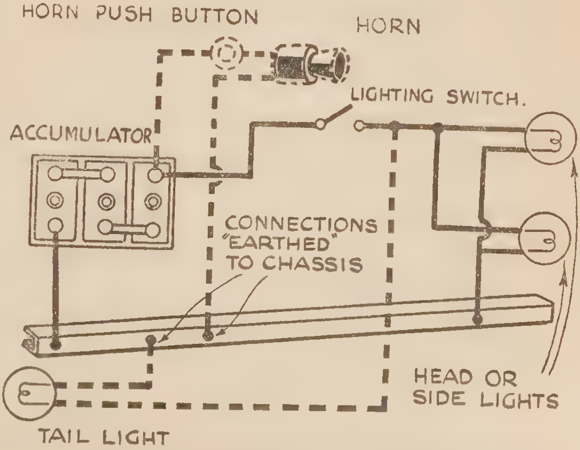


Fig. 119.—The simplest form of car electrical circuit.

ENGINE BALANCE.—As nearly every motorist knows, engine vibration is primarily due to the stopping and starting of the piston at the completion of each stroke. The inertia forces acting on the piston cannot be avoided and the object of balancing is to neutralise their tendency to produce vibration by arranging an equal force acting in opposition to the piston inertia force.

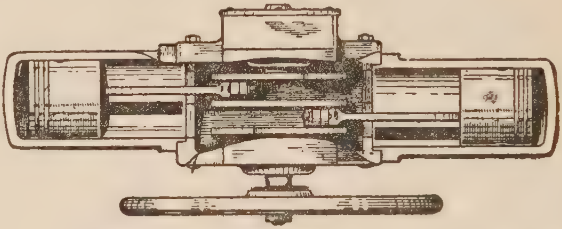


FIG. 120.—Piston arrangement on a horizontally-opposed twin.

Estimating Inertia Forces.—To gain some rough idea as to the magnitude of the inertia forces acting on the piston, let us consider the case of an engine having a stroke of 85 mm.—about the usual figure for a 500 c.c. cylinder. Running at the moderate speed of 2,000 r.p.m. the piston, of course, makes 4,000 strokes per minute and in doing so travels about 1,120 feet; this is its mean speed but the maximum, which occurs near the middle of the stroke, is 1·57 times the mean, in round numbers 1,750 feet per minute or exactly 20 miles per hour. It has to be brought to a standstill at the end of the stroke and has a trifle over 1½ inches to pull up in. Just try to imagine anything travelling at 20 m.p.h. and pulling up in 1½ inches, then accelerating to 20 m.p.h. in the next 1½ inches, but this is what the piston is doing all the time.

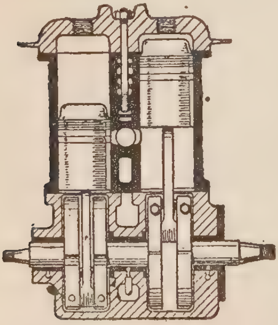


FIG. 121.—Piston arrangement of Side-by-side Twin.

In the case mentioned the machine would be travelling at 34 m.p.h. with a 4½ to 1 gear and 26 inch wheels, but as there is no difficulty in getting twice this speed with a good sports car, then the piston would have to pull up from 40 m.p.h. in 1½ inches.

Naturally quite big forces are brought into play to produce these rapid accelerations and decelerations, in fact, the inertia forces might easily exceed the explosion forces at quite moderate speeds; they would certainly do so in the second case, *i.e.*, with the engine doing 4,000 r.p.m.

If the inertia forces were not balanced in some way the engine vibration would be excessive and would very quickly shake the engine to pieces, to say nothing of the driver's comfort.

Obtaining Balance.—The obvious thing to do to achieve balance is to arrange a second mass equal to that of the piston so that at any instant it is travelling at exactly the same speed as the piston itself but in the opposite direction. This is done in the horizontally opposed twin, the second mass taking the form of another piston (Fig. 120). Both pistons travel outwards together, both stop at the same instant and start the inward stroke together and so on. The "jerk" due to one piston coming to a stop at either end of its stroke is exactly balanced by the "jerk" due to the other piston, they pull one against the other, so that there is no jerk transmitted to the engine or the frame. Each cylinder fires alternately, giving a regular power impulse once per revolution of the engine. In practice, however, the cylinders are not exactly opposite each other, as each piston requires its own crank throw, therefore the balance is not quite so perfect as it might otherwise be; but the cylinders are usually only a little out of line so that the engine still remains practically vibrationless. There are several well-known examples, and it is difficult to understand why this type of engine is not more popular.

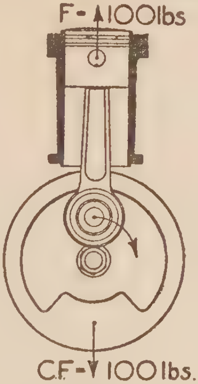


FIG. 122.—Showing how the Flywheel may be weighted to secure balance.

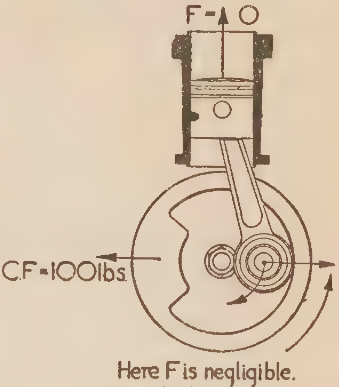


FIG. 123.—This diagram illustrates the condition obtaining after the Crankshaft has made a quarter of revolution.

An Alternative Method of Balancing.—An alternative method of balancing is to arrange two cylinders side by side as in the Scott engine, so that one piston goes up as the other does down (Fig. 121). The balance is not so perfect as in a horizontal opposed twin, for owing to the cylinders being side by side, a rocking couple is set up, but in practice this twin runs very smoothly. This arrangement is not ideal for a four-stroke engine as the power impulses then occur at intervals of ½—1½—½—1½ revs., but the Scott being a two-stroke engine develops a power impulse regularly at every half revolution.

Coming back to the single cylinder engine, this is generally balanced as far as possible by counterweights on the flywheel, but it is not possible to obtain perfect balance by this means for the reason explained below.

Suppose we put a weight on the flywheel so that its centrifugal force is sufficient to balance exactly the inertia force acting on the piston, as shown in Fig. 122. When the engine has turned a quarter of a revolution the conditions will be as shown in Fig. 123; the inertia forces then practically nil because the piston is moving almost at a steady speed, but the centrifugal force is just as great as in Fig. 122. The unbalanced force will therefore be practically the same in magnitude as in an engine without balance weights, but it will act in a direction at right angles to the cylinder bore instead of in the same direction as the bore.

The power impulses in a 90 degree twin occur at intervals of ¾—1¼—¾—1¼ revs.

This section, owing to limitations of space, only deals with primary inertia forces; there are also secondary forces due to the obliquity of the connecting rod, but they are not of great importance on a motor car for in four-cylinder engines they are "swamped" by the primary forces, while on a twin the parts are smaller and therefore the magnitude of the forces less. There is also a tendency to vibration produced by the varying torque reaction; this again is greatest on a single and can only be reduced by increasing the number of cylinders.

The Importance of Piston Weight.—The magnitude of the inertia forces is in each case proportional to the weight ("mass" is more correct) of the reciprocating parts, so it is advisable to keep the piston, complete with rings and gudgeon pin, as light as possible. In a twin engine where one piston is used to balance the other it is important too, that both should be of the same weight. After the pistons are machined they will probably vary slightly in this respect, and when they are for a twin engine they are usually weighed and sorted out into

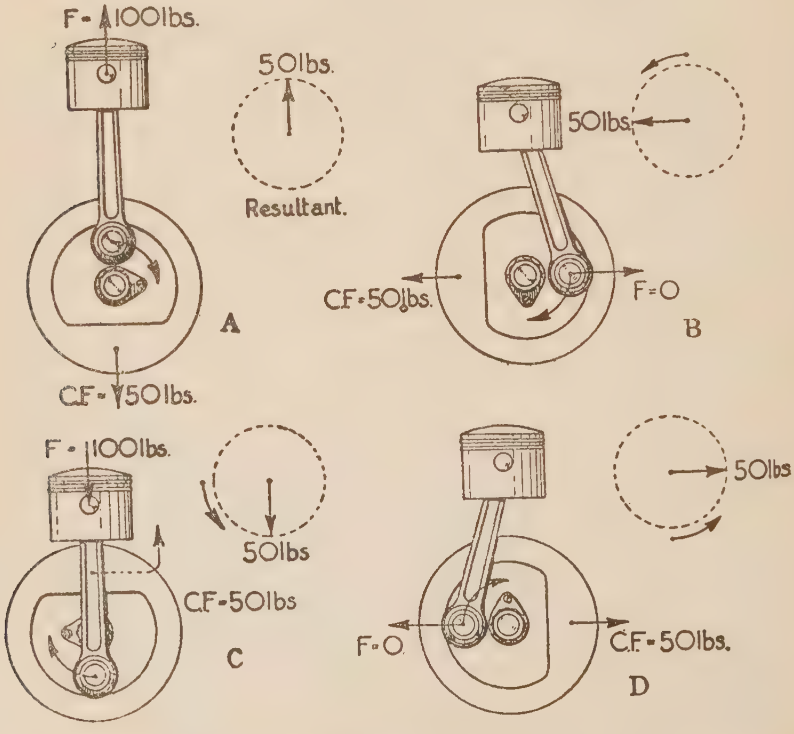


FIG. 124.—Diagram showing how the resultant force rotates in the opposite direction to the Crankshaft when the inertia forces are half balanced.

pairs of equal weight before being issued for assembly.

The same remarks apply to connecting rods except that these are not weighed bodily, for only the little end reciprocates, the big end of course rotating with the crank. The usual method of weighing the " con rod " is to support one end at the same height as the scale pan, resting the other end on the scales; the rod then is in a horizontal position and the little end can be weighed while the big end is on the support and *vice versa*.

If ever it becomes necessary to replace one piston of a twin engine, it is always advisable to see that the replacement is equal in weight (or at any rate very nearly so) to the remaining one. Indeed, it is advisable too with an old engine to see that a replacement is as near as possible equal in weight to the old one, but perhaps it is not quite as important in this case for an old engine always has an unbalanced force and any difference is not so likely to be noticed.

The Importance of Good Balance.—Good balance is particularly important on high speed engines, for the forces vary as the square of the speed. As an instance, one make of touring machine may run quite well at about 2,000 r.p.m., but if the maker decides to ginger up the engine to do 4,000 r.p.m. for a sports model, any unbalanced force will be increased not twice but four times.

Taking all into consideration the most suitable all-round engine for a three-wheeler appears to be a twin, either of the horizontal opposed type or a 90 degree V. The more common 60 degree V is really a compromise which leads itself more readily to conventional frame design. The single is, of course, justifiable on the grounds of simplicity and minimum expense, while a " four " is of course to be preferred. There is not much to choose between a horizontal twin and a four as regards their balance, but the four certainly sounds smoother running and can be more easily silenced.

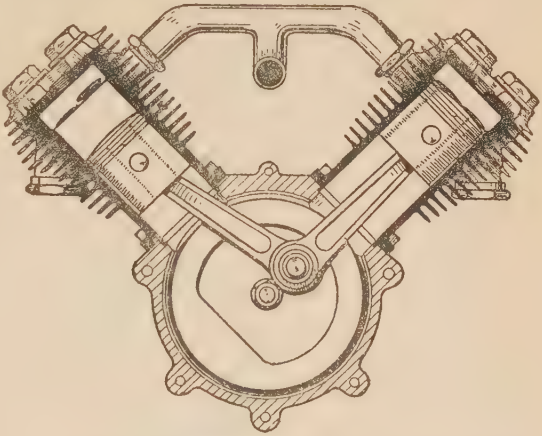


FIG. 125.—Piston Arrangement on a 90° Air-cooled V-twin.

ENGINE-BRAKING.—The braking effect of the engine upon a car's movement downhill due to the energy of motion absorbed by the compression of air within the cylinders, and, to a certain extent by friction within the engine and bearings. It is a useful additional brake in an emergency.

ENGINE LUBRICATION.—In a modern engine the oil is pumped round under pressure to those bearings which have to withstand the greatest wear. Thus, the main bearings of the crankshaft, the big ends of the connecting rods, the gudgeon pins on which the little ends of the connecting rods oscillate. and the walls of the cylinders in which the pistons reciprocate some 2,000 times a minute, require a constant supply of lubricant. The oil must constantly be changed by circulating through the system, cleaned by passing through a filter, and cooled by continually circulating through the sump, which is air-cooled.

Exacting Conditions.—The conditions are rendered exacting by reason of the heat of the cylinders and pistons, due to the burning gas charge ; and so the oil should be of a quality which will remain lubricative, and will not run thin at high temperatures. Such oils are expensive, but, as in the case of so many things connected with motoring, they are the most economical, and may save pounds in repair bills. Do not swill out the sump with paraffin. Run the engine till the oil is warm, next let it run out of the crankcase drain-plug and then fill up with new, clean oil. Do not turn the engine when the oil is out of the crankcase and the pump inside is clear of oil. Air will get in and cause an air-lock and may be the cause of damage to a bearing. When first starting from cold, the pressure gauge will show a big pressure because the cold oil requires much force to send it round through the bearings. After running a little while with no load and not at a high speed, the heat will gradually affect the oil ; it will flow with less resistance and the oil-pressure gauge needle will come back to normal. The engine can then be run at speed and with full throttle (if required) without danger.

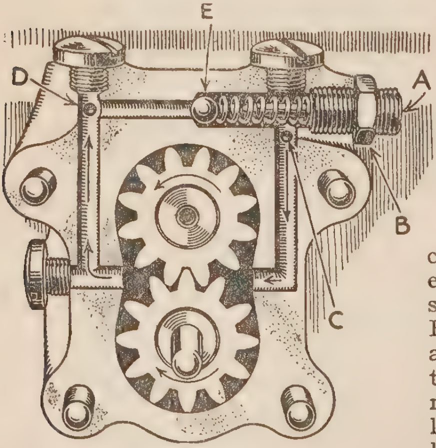


Fig. 126.—The inside of a gear-driven oil pump, showing the non-return valve.

The Pump.—The pump which circulates the oil is of a very simple type and is illustrated in Fig. 126. Two toothed wheels are enclosed in a box which surrounds them. One is driven by a shaft from the camshaft or other rotating member of the engine and it drives the other. Oil entering at A is carried round the casing by the teeth of the gear wheels in the direction of the arrows and forced out at B to the parts which require it. The oil is thus sent round the engine bearings under pressure and at a speed which corresponds with the speed of the engine, so that the faster the engine speed, the more oil is fed through. But engine speed is not necessarily a measure of the amount of lubrication required. An engine may be running at a higher speed with a light load and not requiring much lubrication since the pressures on the bearings are low. On the other

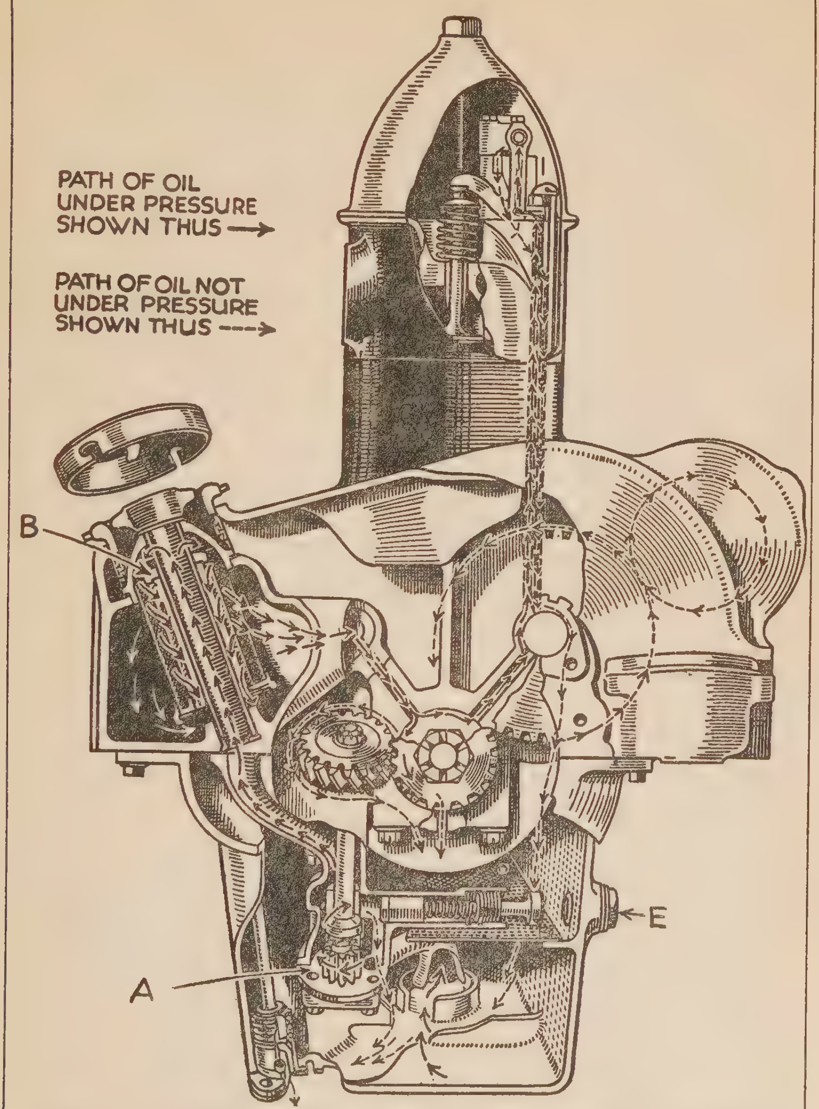

PATH OF OIL
UNDER PRESSURE
SHOWN THUS →
PATH OF OIL NOT
UNDER PRESSURE
SHOWN THUS - - - →
B
A
E

Fig. 127.—Diagram showing the complete lubrication system of a typical engine.

hand, it may be running slowly with full throttle and full pressure on the bearings and require a good supply of oil.

Circulation Adjustment.—Therefore the oil supply is made adjustable within certain limits. In Fig. 126 the pump of a well-known engine is shown with the cover removed. The oil comes in at C and flows down to the centre of the casing. Here it is taken up by the teeth of the two gear-wheels and carried round between the teeth in the direction of the arrows to the other side of the box, where it is forced up and through the outlet D to the bearings of the engine.

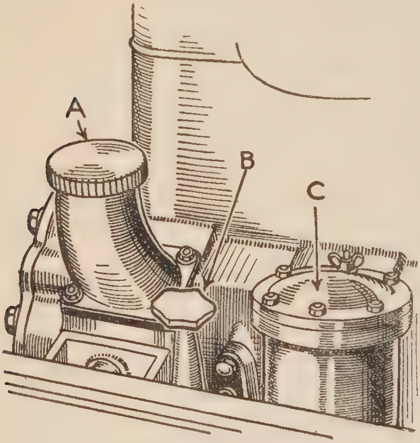


FIG. 128.—This illustration shows the various parts which are referred to in the text.

To ensure against too great a pressure there is a relief valve in a transverse passage connecting the inlet C with the outlet D. This valve consists of a ball E pressed on a seat at the end of the narrow part of the transverse passage by the spring shown. When the pressure of the oil rises (due to excessive speed or other cause) the ball E is pushed off its seat and the oil flows past it to the inlet side of the transverse passage, the ball thus acting as a safety-valve. To allow of adjustment of the pressure at which the ball lifts off its seat—and therefore the pressure of oil circulating in the engine—there is an adjustment by means of which the pressure of the spring upon the ball valve E can be varied. The spring rests against a long screw A, which can be screwed outward to reduce the pressure on the ball valve, and can be screwed inwards to increase it. When the required adjustment has been made it is locked by the lock-nut B (which is threaded on A) in the position in which it is adjusted.

By such a device the motorist can so adjust his oil supply that smoking at the exhaust is obviated. This smoking indicates that too much oil is getting into the cylinder and past the pistons and will cause carbon deposit, misfiring, and overheating. This may also be shown as too much pressure on the oil circulation pressure gauge—if one is fitted— on the dash of the car. The pressure on the ball valve is released by screwing back screw A until the gauge shows a normal working

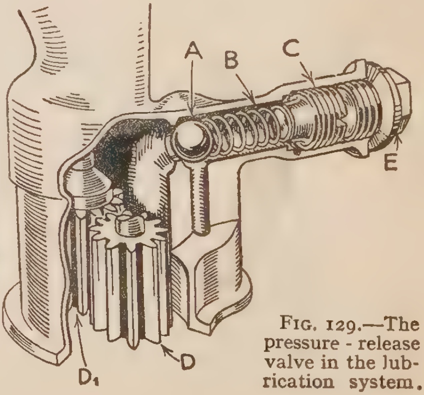


FIG. 129.—The pressure - release valve in the lubrication system.

pressure. And that the gauge pressure may be useful for this adjustment purpose it is necessary that the adjustment should be made when the engine is hot. The appearance of the exhaust will also indicate if too much oil is being delivered, *i.e.* if the pressure is too great. A dark, smoky, and pungent-smelling exhaust will indicate excess. A very light blue smoke, hardly noticeable, will indicate an accurate adjustment of the oil supply. But none of these indications are of any value until the engine has got thoroughly warmed up to normal working temperature.

In Fig. 129 is shown an arrangement which is somewhat similar. The adjustment of the ball release valve A (by altering the tension of the spring) B is effected by screwing, in or out, the screw E, which is accessible to the screwdriver when the cap E is removed. The pump gears are shown at D and D1.

A Modern System.—The way the oil is circulated around a modern engine having overhead valves operated by push rods is seen in Fig. 127, which shows a somewhat similar pump to that just described, *in situ* in the crankcase. The cap E is withdrawn to enable the screwdriver to be inserted to adjust the pump by-pass valve. The pump A, driven by a skew gear-wheel from the crankshaft, draws the oil from the sump and sends it up through a filter B, from whence it passes to oil leads under pressure to the main bearings, up to the big ends, up to the camshaft, and up to the rocker-levers of the push-rod-operated overhead valve gear. It lubricates the gears which drive the camshaft and the engine auxiliaries (dynamo distributor, etc.), and drops down into the sump to be picked up and redistributed, under pressure, through the filter to the essential parts again. An oil-level indicator, which tells the level of the oil in the sump, is an important part of the engine lubrication system, since, should the oil fall below the level of the pump inlet, air instead of oil would be sent round and air locks and perhaps burned-out bearings would result.

The arrangement shown at Fig. 130 fitted to many small cars shows the oil filler A with the detachable filter B, which should never be removed when filling, but which should be occasionally removed for cleaning. It is a fine gauze cup which holds back any solid matter which would interfere with the flow of the lubricative property of the oil. Below is shown the oil-pressure

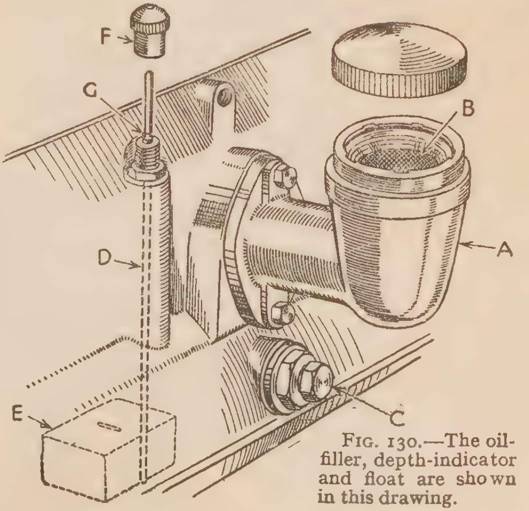


FIG. 130.—The oil-filler, depth-indicator and float are shown in this drawing.

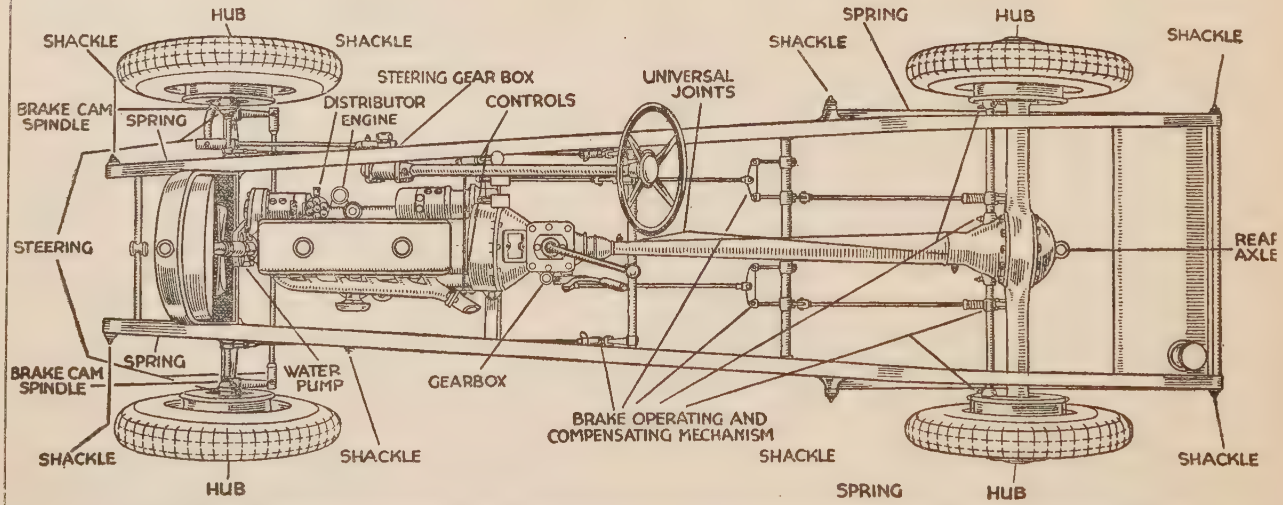

HUB
SHACKLE
SHACKLE
STEERING GEAR BOX
DISTRIBUTOR
ENGINE
CONTROLS
UNIVERSAL JOINTS
SHACKLE
SPRING
HUB
SHACKLE
BRAKE CAM SPINDLE
SPRING
STEERING
REAR AXLE
SPRING
BRAKE CAM SPINDLE
WATER PUMP
GEARBOX
BRAKE OPERATING AND COMPENSATING MECHANISM
SHACKLE
SHACKLE
SHACKLE
SHACKLE
HUB
SPRING
HUB

FIG. 131.—This drawing shows clearly the principal chassis and engine points which require regular lubrication in the interests of economical and efficient running. The motto in all lubrication should be "little and often," since over-oiling or greasing may do as much harm as good.

regulating screw C for regulating the spring pressure on the ball-relief valve, and at the side is shown the measuring rod D attached to a float E in the sump. If the cap F is unscrewed, the float lifts the measuring rod and the state of the oil level is shown by a notch G on the rod, which indicates against the top of the orifice, the lowest advisable level.

The Dipstick.—In Fig. 129 is shown another arrangement, as used on a very well-known car of high grade (the Sunbeam " 25 "). The oil filler A is situated very conveniently on the near side of the engine, and in the big filler neck is a gauze filter easily lifted out for cleaning. A big dipstick (B) is used for indicating the level. In using a dipstick to get accurate results the car should be on a level surface and the engine should be stopped. The dipstick should be lifted out and carefully wiped clear of oil, and then carefully let down its full length into the crank-case and be withdrawn. Unless these precautions are taken an accurate reading cannot be obtained. The wiping of the dipstick is important, for an engine with a low level will show a dipstick well oiled to the top if the engine has only recently been stopped and if the dipstick has not been removed and wiped.

The Oil Filter and Filling.—At C is an oil filter the top of which can be removed to get at the filter element which should be lifted out, cleaned in paraffin or petrol, and carefully replaced. When filling an engine with oil, do not let oil run over any part of the engine. Keep it strictly to the filling orifice. Oil attracts dirt and dust, which may get into the sump and will destroy bearings. Care should be taken to clean oil-filler orifices and caps before removing them to fill up ; so that no grit is washed in with the inflowing oil. Similarly, all cans and containers of oil should be wiped clean before unscrewing the stopper or removing the cork. Cleanliness of the oil should be ensured just as rigidly as if it were milk or a food product. One speck of grit can injure a bearing in an engine, and it can be avoided if the motorist takes care. Keep the oil level in the sump constant and remove the old oil and fill up with new after every 2,000 miles running. That will ensure long life for the engine, and economy of running.

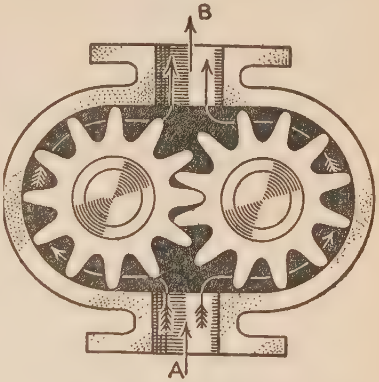


Fig. 132.—Illustrating the action of a gear-type oil pump.

It is of even greater importance to follow the recommendation of the manufacturer as to the grade and make of oil to be used. There is a tendency for the motorist, especially the new motorist, to consider that one oil is as good as another, and that unbranded oils are just as good as more expensive oils. This is a dangerous point of view to adopt, as the motorist soon finds out to his cost. Cheap oils usually give rise to heavy carbon deposits ; they are of low flash point and usually burn, and worst of all they lose their viscosity at low temperatures.

ENGINE TIMING EXPLAINED.—Timing is best left alone when all is well, and the following advice is based on the assumption that the reader has, by some mischance got the wheels or chains mixed up. It is not the slightest use for any owner to imagine that he can improve on the designer's setting. Valves open and close in accordance with the contour of the cam that operates them, and it is not practicable to alter one without the other. It must be remembered that it is not only tappet clearance that governs the silence, or noise, but the shape of the cam itself. If the shape of the cam is such as to let the valve fall very rapidly on to its seat, noise will be set up, and hence, the cam is constructed to let the valve down slowly without much sacrifice of efficiency; therefore you have an "opening-closing-shape-clearance" system to overcome before you can "hot up" the engine in this direction. One can govern the ignition and get much by its manipulation, if only one knows how to do it, but this volume is intended for the owner-driver.

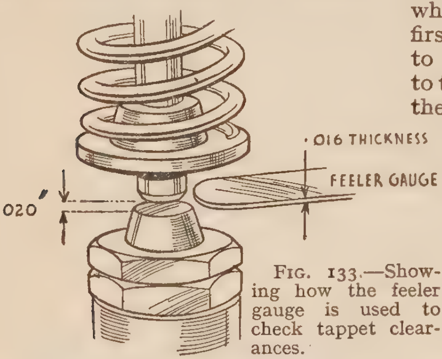


FIG. 133.—Showing how the feeler gauge is used to check tappet clearances.

Valve Timing.—Nearly every car when sold is supplied with a booklet giving full instructions as to both valve and ignition timing, and it is as well to study this part of the book carefully before removing timing cases or chains. The system of showing the valve opening is not always fully understood, and seems mainly for the identification of the mechanic engaged thereon. The sketch shows the valve-timing for the two revolutions of the engine which complete the cycle. The first revolution shows what happens to the inlet valve and the second to the exhaust valve. They perform their work in this order. The position of the spark has been left out so as not to cause confusion but the spark occurs when the second revolution commences, and when both valves are well closed.

According to design, the inlet valve will be found to open just after the piston has reached the top of the stroke, and close some considerable time after the piston has passed the bottom of the stroke. As a matter of fact, the piston is well on its way up the

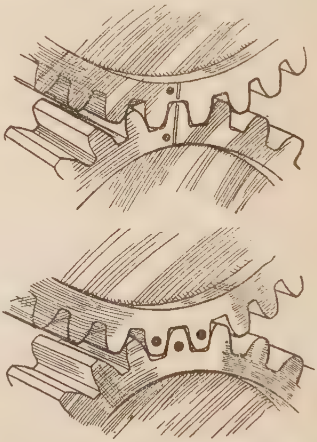


FIG. 134.—Two alternative methods of marking the teeth of timing wheels to simplify reassembly.

cylinder when the valve actually closes. Notwithstanding the fact that the piston moves against the flow of petrolised air it has as yet had no check on the actual flow, therefore, the valve closes late, and when the flow really ceases. The inlet valve is generally open for some 210 degrees out of the 300 degrees of the first revolution. For the remainder of the revolution the piston is occupied in compressing the mixture drawn in, and it is during this time that the spark takes place, although well towards the end. When the effect of the spark is felt the piston has started on the second revolution, the force of the explosion driving it down until the pressure is almost exhausted, when at about 120° down the second revolution the exhaust valve will open, and remain open right past the bottom of the stroke, and not close until the piston has reached the top and expelled the unwanted product of the explosion. Sometimes the valve remains open a little after the top of the stroke—again according to design—but it must be remembered that on the closing of the exhaust valve depends a hot or cool engine. If this valve closes too early some of the hot gas remains behind and causes overheating as well as occupying space that should be filled with fresh and unexploded gas. The valve remains open about 240 degrees.

Exhaust Valve Closing.—In re-timing engines with only one camshaft it is only necessary to observe the action of one valve. Let us assume that we know the exhaust valve closed on top dead centre (TDC) and that the maker's tappet clearance is ·004 in. If the flywheel can be seen, a line also will be seen showing the TDC. If the valve and spring are in place, lower the tappet until there is a clearance of ·020 in., then insert a feeler gauge ·016 in. thick between tappet and valve, and turn the engine until it is pinched by the rising tappet. Turn the engine slowly until you can just pull out the feeler and you have the position of the exhaust valve closing. The flywheel should have reached such a position that the TDC mark has reached the top, or perhaps just started to go down. It will be seen that by using the feeler in the manner mentioned allowance has been made for the makers' correct clearance. This is particularly pointed out as valves move slowly when closing, and a few thousands of an inch of movement of the tappet may mean a lot on the flywheel. Under no circumstances should you be able to remove the feeler until TDC on the flywheel has come to the top.

In using the inlet valve for re-timing, exactly the opposite takes place, the feeler being pinched between tappet and valve at the correct moment of opening and released when it closes.

When There Are Two Camshafts.—It may be that one has an engine with two camshafts, and the timing is definitely unknown. The difficulty here is not only to find when each set of valves should operate, but to find out how long they remain closed and open, and this must be found before any decision is arrived at as to the actual opening or closing. Insert the inlet camshaft gear wheel in mesh and, using the feeler system already described, make a mark on the flywheel where the valve commences to open, and another mark where it closes. By measuring the distance between the marks and making a simple calculation, the number of degrees the maker intended the valve to remain open can be obtained. Do exactly the same with the exhaust camshaft. Draw three circles on paper and mark one circle with TDC and Bottom Dead Centre (BDC). On one of the others mark out the degrees of opening of the inlet valve and cut out with scissors, also cutting away that portion of the valve which is not in operation. Do the same with the exhaust valve circle and mark them both so as not to get mixed up. Lay them on the first circle, using a pin for a pivot, and see what they look like against a standard timing. By this one will get a fair idea as to what to do in the actual setting.

If the period of opening is long it may mean a slow opening or closing, or both. The opening of the inlet and the closing of the exhaust may overlap. A good tip is to be guided mainly by the closing of the inlet valve and the opening of the exhaust, but there can be no hard and fast rule. When assembling for trial be sure to keep a record so that engine performance can be noted and errors properly corrected. An inlet-valve test is to turn the engine slowly with a piece of paper held over the inlet port. If the valve opens too early the paper will be blown away from the port by the rising piston.

Mark the Wheels Before Dismantling.—As an illustration of extraordinary valve opening, the inlet valve on a large and well-known engine remains open 275 degrees. Opening takes place some 5 degrees before TDC and closing, 90 degrees after BDC. This valve closes very slowly indeed, especially towards the end of its movement, but is an illustration of the problem to be met when dealing with unknown quantities.

Before removing a wheel or a valve one should test out the opening so that the exact position is known before dismantling takes place. Wheels with teeth for direct engagement with other wheels are invariably marked, but wheels that carry chains are seldom so marked.

When timing is carried out by measuring the stroke instead of the flywheel it is easy to divide the length of the stroke by 180, so giving the movement of the piston per degree, but the method is not truly accurate and an approximation can only be attained. The reason for this is that the piston moves faster during the top half of the stroke than during the bottom half, causing the piston to be more than half way down the cylinder when the crank-pin is at 90 degrees.

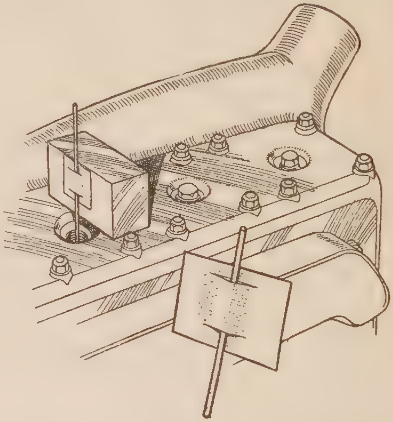


FIG. 135.—This diagram shows the simple gauge referred to for determining the position of the pistons in their bores.

All plugs should be removed so that the engine turns freely. Remove the setscrew from the top of the water-jacket and pass through the hole a stiff piece of wire about 3-32 in. diameter. It should slide up and down without friction as the bottom end is pushed up and then allowed to fall down again by the movement of the piston. A piece of white cardboard slit in two places and threaded over the wire will act as a tell-tale as it passes some suitable object placed on the cylinder block. The tell-tale can be moved about until it reaches the edge of the object when the piston is at the top of the stroke. As a rule the inlet valve opens when the piston is on TDC, and if ignition is fixed, as it is with many European engines, the contact-breaker points should be made to open at 6 mm. before TDC.

USEFUL FORMULA CONNECTED WITH ENGINE TIMING

Required value of 1 *degree around flywheel* =

$$\frac{\textit{Diam. flywheel} \times 3{\cdot}1416}{360}$$

Required distance around flywheel for obtaining Equivalent number of degrees =

$$\frac{\textit{No. degrees. required} \times \textit{diam. flywheel} \times 3{\cdot}1416}{360}$$

Required degrees around flywheel with known distance =

$$\frac{\textit{Known distance} \times 360 \times \textit{diam. of flywheel}}{3{\cdot}1416}$$

Ignition Timing.—Regarding ignition timing, magnetos are generally arranged to advance the spark over a 30-degree range, therefore the points should be made to open on TDC when the contact-breaker is placed in the retarded position. As magnetos always work at their best in the advanced position, and also, as the range of the magneto may not be known, it is best to time the engine by marking off 30 degrees before TDC. on the flywheel and fitting the magneto, having the contact-breaker in the advanced position. With fixed magneto ignition, the marking should be at 27 degrees, as any place above this is likely to lead to a back-fire when starting. These remarks also apply to battery ignition when hand-controlled and fixed, but there are now variations in that we have both semi- and full-automatic. The best advice if there are no written instructions with either of these, is to time on TDC and try on the road. It is quite easy to undo the screw and advance the timer a little if necessary. Intermittent sparking at medium and high speeds is often due to wear of the bushes and spindle of the timer. This can only be dealt with by official repairers, also it does not come within the scope of this section.

On engines fitted with shrouded inlet valves the maker should be consulted before any attempt is made to time. The few that have been met with have all been different and seem to follow no orthodox method.

EPICYCLIC GEAR. — Another name for Planetary Gear, which see. An epicycle is a circle having its centre on the circumference of a larger circle on which it moves.

ERG.—The absolute unit of work. It is the work done by a force of one dyne in acting for a distance of one centimetre.

For practical purposes this unit is too small and is replaced by the joule.

From the Greek, *Ergon*, work.

See *Joule*.

ESSENCE.—A term of French origin occasionally used in this country to describe petroleum spirits and similar motor fuels.

ETHYL ALCOHOL. — Chemical formula: $C_2H_5{\cdot}OH$. A colourless pleasant-smelling inflammable liquid. Boiling point, 78°C. Specific gravity, 0·806. The main constituent of alcohol fuels.

ETHYLENE.—Chemical formula: C_2H_4. A colourless, invisible hydrocarbon gas possessing a peculiar sweet smell. It forms the starting point in one process for the synthetic manufacture of fuel alcohol.

Traces of ethylene are also sometimes found in the exhaust gases of petrol engines.

ETHYLENE DIBROMIDE. — Chemical formula: $CH_2Br{\cdot}CH_2Br$. As ordinarily made, this is a heavy reddish liquid of boiling-point 131°C. With ethylene dichloride it is mixed with lead tetraethyl in the preparation of anti-knock petrols.

ETHYLENE DICHLORIDE. — Chemical formula: $CH_2C1{\cdot}CH_2C1$. A colourless oily liquid of specific gravity 1·2 and boiling-point 85°C. At one time called " Dutch Oil " on account of its original discovery by Dutch chemists. Together with ethylene dibromide, it is mixed with lead tetraethyl to form an anti-knock preparation for adding to petrol.

EXHAUST. — The conduit through which the exhaust gases from the cylinders pass to the outer air.

The name is also applied to designate the exhaust gases themselves.

EXHAUST GASES.—The products of the explosive or rapid combustion taking place within the cylinders. Exhaust gases are normally composed of carbon dioxide, carbon monoxide, steam, nitrogen, together with varying amounts of oil vapour, and traces of unburnt fuel and hydrocarbon gases. On account of their carbon monoxide content, they are highly poisonous.

EXHAUST HORN.—See *Exhaust Whistle.*

EXHAUST PIPE. — The pipe which conveys the exhaust gases of the cylinders to the silencer and from thence to the outer atmosphere.

EXHAUST PORT.—See *Port.*

EXHAUST STROKE.—The upward stroke of the piston which pushes out through the raised exhaust valve the burnt charge within the cylinder.

EXHAUST VALVE.—The cylinder valve of the engine which is made to open once for every two revolutions of the flywheel in order to permit of the escape of the combusted mixture.

EXHAUST WHISTLE. — The name given to a sound-producing device which is operated by the current of exhaust gases from the engine. It is fixed to the end of the exhaust pipe and is controlled by means of a pedal or a small lever fixed at the driver's seat.

Exhaust whistles are sometimes attached to heavy vehicles, but they are seldom used for cars.

EXPANSION.—The increase in volume of a material which occurs when it is heated.

The power developed by the ignition of the fuel mixture within the cylinder is mainly due to the heat generated during the rapid chemical combination of the constituents of the vapour.

EXPLOSION. — In connection with motoring matters, this term usually refers to the rapid chemical combination, accompanied by violent expansion, of the vapourised fuel and air mixture within the cylinder.

F

FABRIC CLOTH.—See *Leather Cloth.*

FABRIC FINISH.—Term applied to a type of covering or finish given to car-bodies. It comprises dissolved cellulose or cotton material which has been spread over a cloth base so that it fills up the pores and presents a fairly hard and weatherproof surface.

See *Cellulose Finish.*

FABRIC JOINT.—A form of universal joint consisting of discs of fabric composition which are interposed between the opposite end-pieces of the revolving shafts.

See *Universal Joint.*

FACIA BOARD.—An up-to-date name for the instrument board of a car—the Dashboard.

FAHRENHEIT.—The scale of temperature introduced by Gabriel Fahrenheit (1686-1736), a German scientific-instrument maker, and now employed exclusively in this country for all ordinary purposes.

On the Fahrenheit scale the freezing point of water is 32°, the boiling point of water being 212°.

Car thermometers are usually graduated in degrees Fahrenheit, although attempts are frequently made to displace this temperature scale for the simpler Centigrade one.

See *Centigrade.*

FAN.—Term referring to a revolving fan worked, generally, off the front end of the engine crankshaft and mounted between the cylinder-block and the back of the radiator.

Its purpose is to assist with the cooling of the engine, thus avoiding the use of a larger radiating surface to the water-cooling system.

FAT SPARK.—A term which describes an electric spark at the plug points which, though short in length, has a relatively great width. Such sparks are always desirable for ignition purposes within the cylinder. The thickness of a spark usually depends upon the strength of the current, other factors being equal.

FEATHER.—Name given to a key which secures a revolving member to a shaft in such a manner that it can move along the shaft.

Examples of feathers are to be seen in gearboxes of many types in which the wheels are required to be capable of movement along the shafts.

FEATHER-HEADED BOLT. — An ordinary bolt which carries a small projection just beneath the head. This projection slips into a slot in the material into which the bolt is inserted, thus preventing its rotation when the nut is being screwed up.

FEED PUMP.—A pump which regularly supplies liquids to a given spot in order to make up for similar liquids which are being used up continually. In automobile construction, oil pumps are usually of this general nature.

FEELER GAUGE.—Name given to a set of metal strips of varying thicknesses which are inserted between the tappet and the valve stem by way of trial in order to ascertain the amount of clearance existing between the two parts.

FERRO-CHROMIUM.—An alloy of iron and chromium, containing about 60 per cent of the latter, from which chrome-steels are made.

See *Chrome Steel.*

FERRO-VANADIUM.—An alloy of iron and vanadium used in the manufacture of vanadium-steels.

See *Vanadium-Steel.*

FIBRE.—A term used to denote various fibrous materials usually consisting of compressed chemically-treated paper with which is sometimes incorporated cellulose material. Fibre compositions of this nature are much used in the making of washers and packings.

FIELD MAGNETS.—Name given to the permanent magnets of a magneto. They create a " field " of magnetic influence around the armature of the magneto.

FILAMENT. — The thin wire thread which glows under the heating effect of the current within the bulb of an incandescent electric lamp.

FILLER-CAP.—The metal cap which screws over the filling orifice of fuel and oil tanks and radiator systems, thus preventing the ingress of foreign matter and the escape of the liquid therein.

FILM RADIATOR.—See *Ribbon Radiator.*

FINAL DRIVE.—Term used to denote the back axle mechanism of a car by which the final transference of engine-power to the road wheels is made.

FINGER NUT.—An alternative name for *Wing Nut,* which see.

FINS.—Name given to the metal ribs or flanges which are formed on the exteriors of air-cooled cylinders and in adjacent positions. Their object is to present as great a surface as possible to the cooling action of the air.

FIRING POINT.—See *Ignition Point.*

FIRING STROKE.—See *Ignition Stroke.*

FLAME FRONT.—The face or front of the flame as it spreads evenly and rapidly downwards from the plug points through the combustible mixture in the cylinder.

FLANGE. — A circular-shaped plate attached in one way or another to the end of a pipe. The flange is usually drilled with holes and by means of it the pipe is secured to another member or to a similarly flanged pipe by means of bolts passing through the holes in the flanges.

FLASH-POINT. — The temperature at which an inflammable liquid such as petrol, or an oil when slowly heated in an open vessel begins to evolve sufficient vapour to burn with a momentary flash when a naked flame is brought into contact with the vapour.

The flash-point of a fuel or an oil should be carefully distinguished from the ignition-point, which is the temperature at which the vapour takes fire and continues burning.

FLEX.—The common abbreviation for flexible multi-strand electric wire usually comprising two such cables twisted together.

FLEXIBLE JOINT.—Applied to a power shaft or similar device, this term denotes some type of universal joint, which see.

FLOAT.—The light hollow metal box which, forming part of the carburettor, regulates the supply of petrol to the float chamber.

FLOAT CHAMBER.—The metal case or cylinder in which the carburettor float is housed and which serves as a reservoir for the supply of petrol to the jet or other vapourising device of the carburettor.

FLOAT FEED.—A term referring to carburettors in which the level of the petrol in the instrument is maintained by means of a rising and alling float. (See *Float.*)

FLOATING AXLE.—A type of back axle construction in which the total rear weight of the car is borne by the axle casing, thus leaving the road-wheel axles free to revolve without supporting any weight.

This type of back axle construction is known, also, as the " Full-Floating axle " to distinguish it more strictly from the semi-floating axle and the three-quarter floating axle. (See *Back Axle.*)

FLUID FLYWHEEL TRANSMISSION.—Name given to a power transmission system evolved by the Daimler Company in which engine-power is transmitted to the car road-wheels without the intervention of a clutch.

FLUID FLYWHEEL EXPLAINED.—Ever since cars were produced, designers have been searching for a method of transmitting the engine power to the road wheels, without the use of a clutch. Many systems have been patented, but the Daimler Company were the first to produce a range of cars where the normal type of clutch is eliminated.

The main advantage of the fluid flywheel is that it cuts out clutch operation altogether. The connection between the engine and the gearbox is automatic, and its efficient control is not dependent on the skill of the driver, as is the case with the normal clutch mechanism. When the accelerator is released the fluid flywheel disconnects the drive, and when it is depressed the drive is taken up without any other action on the part of the driver. To drive the car in a normal manner no skill is required on the part of the driver, though an expert can obtain improved performance if he so desires.

The principle on which the fluid flywheel works is basically that of the water-mill. The old style miller arranges his water-wheel so that the bottom of it is in a flowing stream. The wheel has projecting paddles and water striking these causes the wheel to revolve. If the flow of water is very slow, it may not hit the paddles with enough force to turn the wheel. On the other hand, the faster the flow of water, the harder it will strike the paddles and the faster the wheel will revolve. Applied to the fluid flywheel, when the water is too slow to turn the wheel, we have the neutral position, and if we can imagine the water in the stream rapidly flowing faster and faster thus turning the wheel with increasing speed, we have the condition when the car is accelerating. A steady flow of water will mean a steady speed of the wheel, and here we find the same state when the car is cruising along in top.

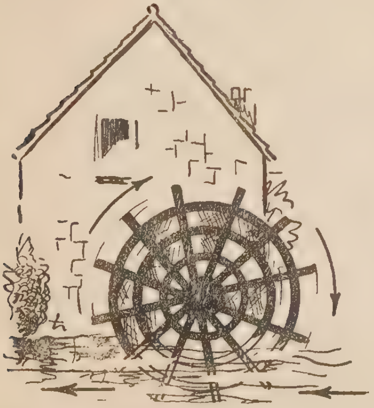


FIG. 136.—The water-mill provides the basic principle of the fluid flywheel clutch.

The Two Parts of the Fluid Flywheel.—A fluid flywheel consists of two parts. The driving member is rigidly connected to the engine crankshaft, and the driven member to the gearbox These two members are shown in Fig. 137, and are so mounted that there is a small gap between them. The engine, therefore, has no mechanical connection with the gearbox. The casing round the clutch is oil-tight and nearly full of ordinary engine-oil. It will be seen that the driven member has a number of vanes fitted inside the rim. The driving member has a number of pockets round its outer edge. Remember that the whole mechanism is immersed in oil, and imagine what will happen when the engine is started and the driving member rotates. The pockets will be filled with oil and the centrifugal force caused by the rotation will tend to fling the oil outwards. But the pockets are so shaped that the oil is flung to on the

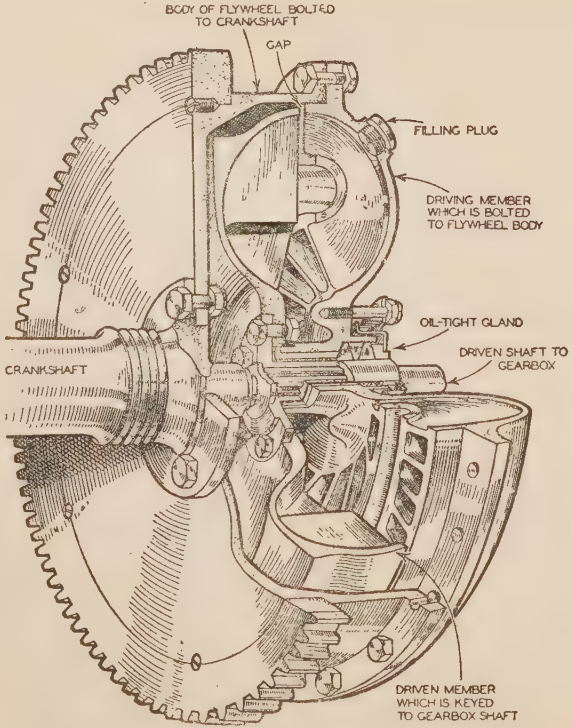

BODY OF FLYWHEEL BOLTED TO CRANKSHAFT
GAP
FILLING PLUG
DRIVING MEMBER WHICH IS BOLTED TO FLYWHEEL BODY
OIL-TIGHT GLAND
DRIVEN SHAFT TO GEARBOX
CRANKSHAFT
DRIVEN MEMBER WHICH IS KEYED TO GEARBOX SHAFT

Fig. 137.—Cut-away view of the fluid flywheel clutch.

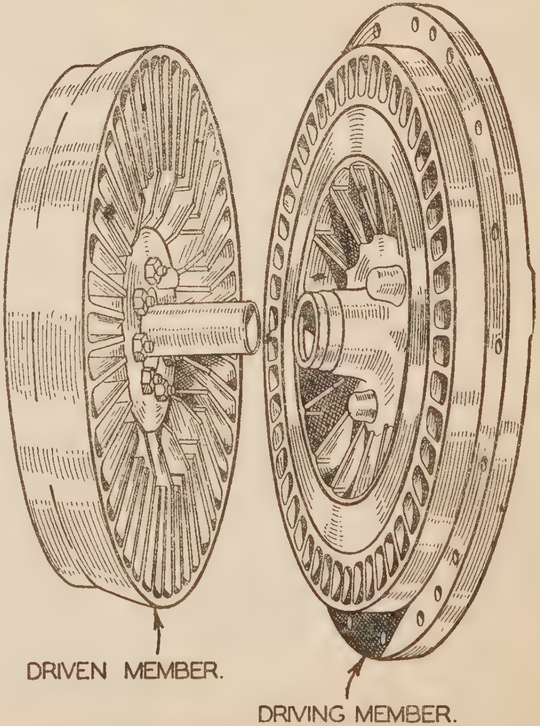

DRIVEN MEMBER.
DRIVING MEMBER.

Fig. 138.—The driving and driven members of the fluid flywheel clutch.

vanes of the driven member. Now when the engine is idling the force behind this oil stream is not enough to turn the driven member, and the car can, therefore, be held stationary, even though it is in gear, by the light application of the hand-brake. But as the engine speed is increased, the oil is thrown with greater and greater force at the vanes of the driven member, thus causing it to rotate. It will be seen that when the car is stationary and the engine is speeded up a large amount of slip takes place between the two members of the flywheel. This has the effect of reducing the gear, and also of taking up the drive very sweetly. As the speed of the car increases the slip becomes less and less, until, when a normal speed is reached, it is imperceptible, being only about 2 per cent.

After the oil has impinged on the vanes of the driven member, its energy is expended and it falls to the middle of the flywheel to be picked up again by the driving member. When the car is in motion the action of the fluid flywheel is so rapid that a constant stream of oil is thrown off by the pockets on the driving member. This stream strikes the vanes on the driven member and then is picked up again by the pockets in the driving member, and goes through the whole process again. Thus the stream of oil assumes the shape of a spiral, threaded in and out of the pockets and vanes of the two members. The fluid flywheel is reversible, so that the engine can be used as a brake in the normal manner. When going downhill with the foot off the accelerator the oil is thrown by the vanes on the member fitted to the gearbox into the pockets in the member fitted to the engine. The car, therefore, runs against the compression, as in a car with the old style of clutch.

Improved Acceleration.—Owing to the fact that the flywheel accommodates itself to the load, acceleration is improved. It has the effect of a variable gear, because the slip becomes less as the speed of the car increases.

With a fluid flywheel a gearbox is not a necessity in flat country A car without one would be a very tame affair, however, and unless the rear axle ratio was low, very steep hills could not be climbed. In order to obtain good performance a four-speed pre-selective gearbox is fitted to the B.S.A., Lanchester, Daimler productions, all of which have the fluid flywheel. The combination of these two valuable improvements makes a car very simple to drive, without detracting in any way from the improved performance which is usual with any car when an expert is at the wheel.

As there are no parts to wear, the fluid flywheel needs no overhauling or special attention. There are no adjustments and, beyond seeing that the oil-level is correct, no service of any kind is necessary. The clutch operation being entirely done away with, driving in traffic is less fatiguing, and the novice can move off with the smoothness of the experienced driver.

FLUTES.—An engineering term used to describe the grooves which form the cutting edges of taps.

FLUX.—Name given to a class of materials which are used in the soldering, welding or brazing of metals. They include resin, ammonium chloride, hydrochloric acid (spirits of salts), borax, etc., the type of flux used being governed by the nature of the metal and the process of uniting it.

FLYWHEEL.—A heavy steel or cast-iron wheel mounted on the main shaft of the engine, the purpose of which is to even up the intermittent power impulses given to the crankshaft by the pistons. The flywheel gives the character of steady-running to the engine. (See *Fluid Flywheel.*)

FOCUS.—The point at which rays or lines meet. The point at which rays are collected after being reflected or refracted.

An electric headlamp bulb of a car, for instance, is in focus with its reflector when it is placed in such a position that the rays of light from the reflector converge to a point in the space occupied by the bulb.

FOOT.—An English measure of length or distance. One foot equals 12 inches, ⅓ of a yard, or 30·47 centimetres.

Originally this standard of measurement was derived from the average length of a man's foot.

FOOTBOARD.—The wooden or metal board running across the front portion of the floor of the car below the front seats through which the steering column and the foot controls pass.

FOOT-POUND.—A unit of power. One foot-pound per minute represents the power necessary to lift a weight of 1 pound to a height of 1 foot in 1 minute of time.

One horse-power is equal to 33,000 foot-pounds per minute.

See *Power, Horse-power.*

FORCED INDUCTION. — See *Supercharging.*

FORCE FEED LUBRICATION.—The modern system of engine lubrication whereby oil contained in the crank chamber of the engine is drawn up by a mechanical pump and forced under considerable pressure to the main bearings of the engine. (See *Engine Lubrication.*)

FORGE.—To shape wrought steel or iron by heating and afterwards by stamping, pressing or otherwise forcing through dies or by otherwise working with heavy hammers, etc. Any ductile metal can be forged, although, usually, the term is reserved for iron or steel articles which have undergone this treatment.

FORGING. — The shaping of metals by hammer blows, the process generally being carried out whilst the metal is in a red-hot condition. Iron and mild steel are the metals which are generally subjected to this process.

FORK.—A rod, bar, or lever possessing a forked or V-shaped extremity. A rod of this description enters into many clutch-operating mechanisms.

FORMITE.—A type of Bakelite material used for the production of parts for fittings and accessories.

See *Bakelite.*

FOUR-STROKE CYCLE. — The cycle of operations taking place within the cylinder of an internal-combustion engine whereby continuous power is developed.

This sequence of operations necessitates four successive strokes of the piston to complete it—the induction, compression, power and exhaust strokes. Hence the name by which the cycle is known.

Most car engines operate on the four-stroke cycle. They are thus sometimes known as four-stroke engines. (See also *Two-Stroke Cycle.*)

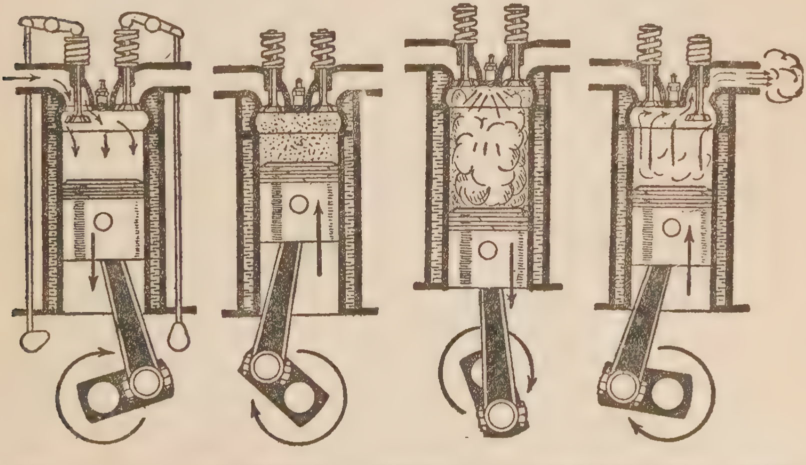
See *Otto Cycle.*

The following explanations of the principles of the four-stroke and two-stroke engines also include descriptions of the complete mechanism of the car, as it is thought that the reader will gain a better knowledge of the principle of the motor car than by consulting the separated descriptions governed by the alphabetical arrangement of this book.

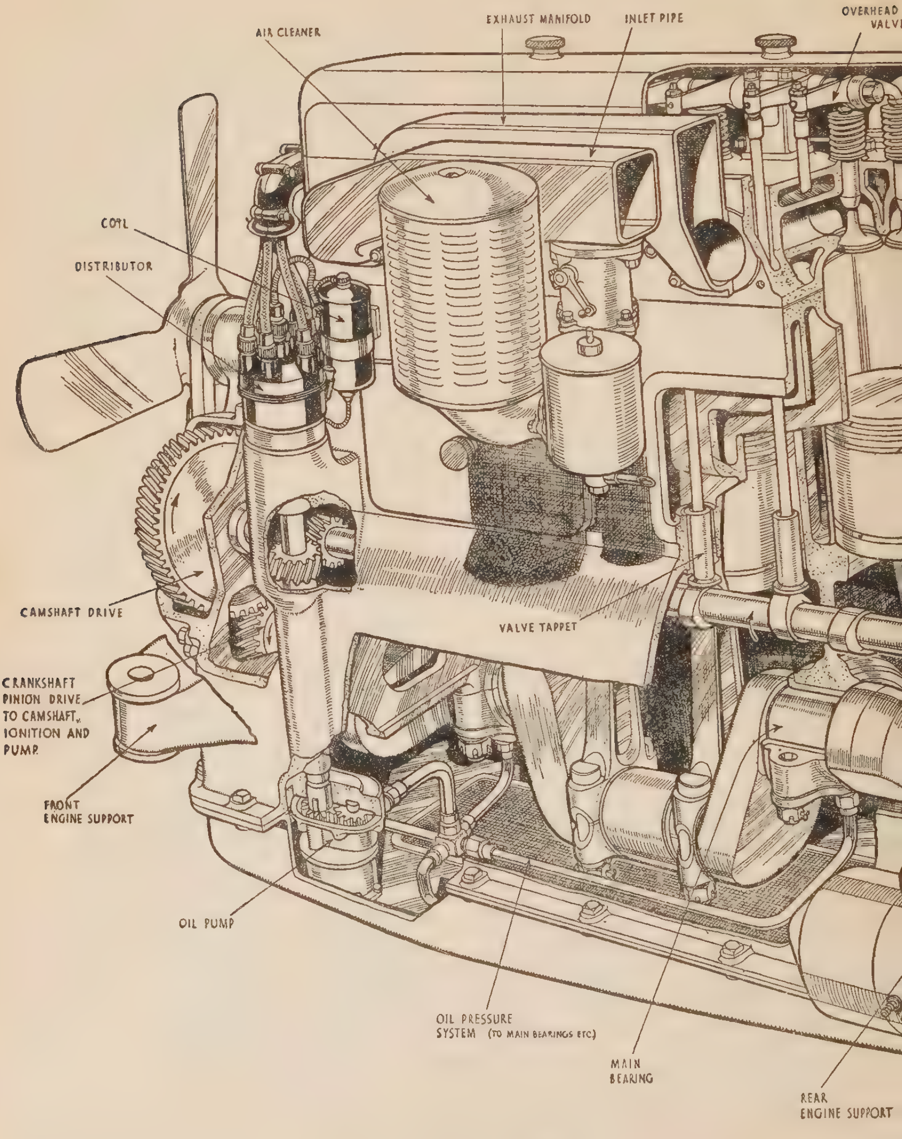
FOUR- AND TWO-STROKE PRINCIPLES.—Although there is an almost bewildering variation in the detail design of car engines, all of them work on one of two principles—the four-stroke system and the two-stroke system. Most of them work on the former principle and only one or two of the cheaper makes on the latter principle; and as the basis of correct adjustment and repair is a knowledge of first principles, this section briefly explains these two fundamental systems. It must be clearly understood that this explanation holds true for any engine, irrespective of the number of cylinders or the valve arrangement. In order to simplify this explanation, the action of a single cylinder is taken; it will, of course, be realised that the same action takes place in each cylinder.

In every cylinder is a piston secured to the crankshaft by a connecting rod. As the crankshaft rotates, the piston is moved up and down in the cylinder. In each cylinder-block two valves are arranged, one an inlet valve and the other an exhaust valve (sometimes four—two of each). Geared to the crankshaft is a camshaft, and the cams on this latter are so arranged that the valves are opened and closed at certain intervals. Above each cylinder (although sometimes they are fitted in the side of it) is a sparking-plug connected by a rubber-covered copper wire cable to the magneto (or coil), and ports or openings controlled by the inlet valves are connected by means of an induction pipe to the carburettor, Other ports or openings controlled by the exhaust valves lead, via the exhaust manifold, to the silencer and exhaust pipe.

The ignition system may be either high-tension (high-voltage) magneto or coil; but whichever



FIGS. 139 to 142.—The principle of operation of the Four-stroke engine, showing (*left to right*) induction, compression, firing, and exhaust strokes. Note position of inlet and exhaust valves.


AIR CLEANER
EXHAUST MANIFOLD
INLET PIPE
OVERHEAD
VALV
COIL
DISTRIBUTOR
CAMSHAFT DRIVE
VALVE TAPPET
CRANKSHAFT PINION DRIVE TO CAMSHAFT, IGNITION AND PUMP
FRONT ENGINE SUPPORT
OIL PUMP
OIL PRESSURE SYSTEM (TO MAIN BEARINGS ETC)
MAIN BEARING
REAR ENGINE SUPPORT

system is employed it is driven, as is the camshaft, at half crankshaft speed. Having briefly explained these facts, we can now proceed to an explanation of the four-stroke principle. The four strokes are, respectively, the induction, compression, power, and exhaust strokes. These four strokes take place once in every two revolutions of the crankshaft, or once in every four strokes of the piston. One revolution of the crankshaft moves the piston up and down the cylinder (two strokes). The first stroke is the induction stroke in which the downward stroke of the piston induces or draws air through the carburettor, and in doing so carries with it a certain amount of petrol which is "lifted" from the jet. The cam operating the inlet valve is so arranged that it lifts the inlet valve off its seating during this stroke, and the mixture of petrol and air is thus drawn into the cylinder. When the piston reaches the bottom of its stroke (bottom dead centre) the cylinder is, of course, full of petrol-and-air gas, and the inlet valve then closes, trapping the gas in the cylinder. (*See* Figs. 139 to 142.)

The piston now commences to travel to the top of the cylinder, and in so doing it compresses the gas, for both valves are closed and it has no means of escape. This is the compression stroke; and when the piston has nearly reached the top of the compression stroke (top dead centre) a spark occurs at the points of the sparking-plug, thus igniting or firing the petrol-and-

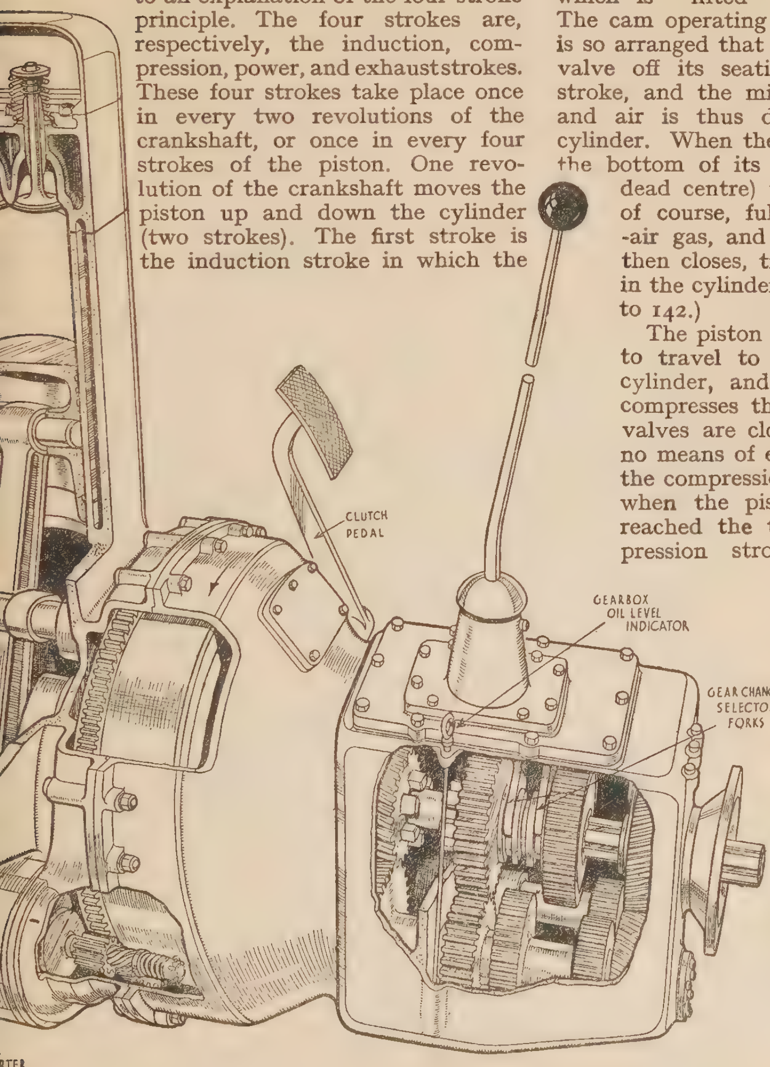


Fig. 143.—Cut-away view through a Modern 4-cylinder Engine.

air gas, and forcing the piston (which has now passed over top dead centre) down again provides the power which, delivered to the rear wheels via the clutch, gearbox, propeller shaft and differential gear, drives the car along. This is the power stroke. Just as it reaches bottom dead centre, the exhaust cam lifts the exhaust valve off its seating, thus enabling the burnt gases to escape into the exhaust system, from which it passes to the air. This is the exhaust stroke; and when the piston reaches the top of the exhaust stroke, the inlet valve opens, a fresh charge of gas is drawn from the carburettor into the cylinder, and a fresh cycle or sequence of strokes is commenced. This cycle of operations continues whilst the engine is running. In order that the utmost power be obtained from each cycle, the spark must occur before top dead centre (ignition fully advanced), and the opening and closing of the valves (the valve timing), needs to be precise. Fortunately the valves are timed for efficiency by the makers and cannot go out of adjustment.

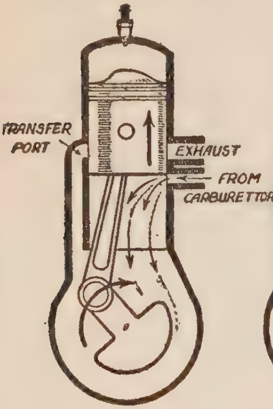


Fig. 144.—Induction from carburettor into crank-case.

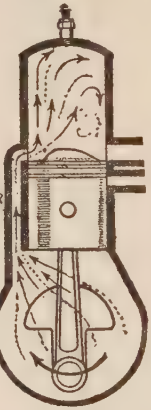


Fig. 145.—Transfer of gas from crank-case to cylinder.

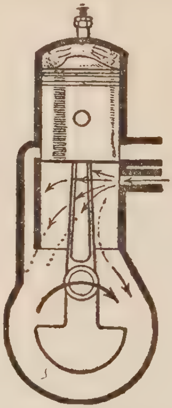


Fig. 146.—Firing of charge and inlet from carburettor in to crank-case.

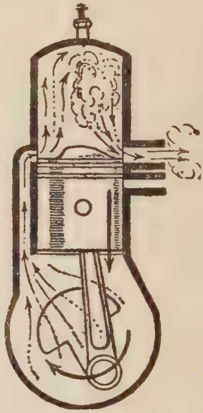


Fig. 147.—Exhaust and transfer of fresh charge from crank-case.

The Two-Stroke Principle.—The two-stroke engine is much simpler in operation than the four stroke. The two stroke is so named because it has a power stroke to every two strokes of the piston, or every single revolution of the crankshaft. It is remarkably simple in action, and is sometimes referred to as a valveless engine, because it has no valves properly so described. The piston carries out the function of inlet and exhaust valves, and because of this, much less power is lost. There are many inherent disadvantages, however, which must be set against the saving of power in this direction. Figs. 144 to 147 show the two-stroke principle diagrammatically. It will be seen that the essential parts are an intake port or opening connected to the carburettor, an exhaust port, immediately above it, and a transfer port or passage connected with the crank-case.

In Fig. 144 it will be seen that the piston is approaching the top of its stroke, and has uncovered the inlet port ; this upward action induces or draws a charge of petrol-and-air gas from the carburettor into the crank-case. Notice that exhaust and transfer ports are closed.

In Fig. 145 the piston has descended thus closing the inlet port and compressing the gas in the crank-case. When it reaches the bottom dead centre, the top of the piston uncovers the transfer port, thus allowing the gas in the crank-case to flow, or transfer itself into the combustion chamber.

The piston now commences to travel upwards again and the piston thus closes the transfer port, so trapping the gas in the combustion chamber, where the upward movement of the piston compresses it.

Fig. 146 shows the compressed

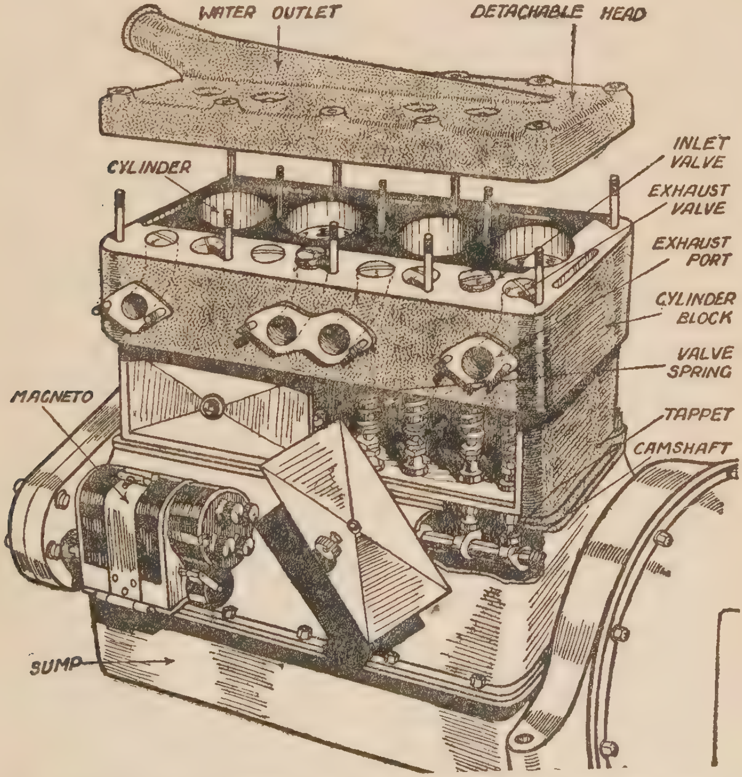

WATER OUTLET
DETACHABLE HEAD
INLET VALVE
CYLINDER
EXHAUST VALVE
EXHAUST PORT
CYLINDER BLOCK
VALVE SPRING
MAGNETO
TAPPET
CAMSHAFT
SUMP

FIG. 148.—Typical Four-cylinder Side-valve Engine, showing some of the principal parts. Path of exhaust ports is shown by the dotted lines. The inlet ports are grouped together into one passage passing between the two centre cylinders to the off side and so to the carburettor, which is bolted direct to the block.

charge being ignited, and at the same time a fresh charge from the carburettor enters the crank-case. Again the piston descends, and when reaching the bottom of its stroke the burnt gas is expelled and a fresh charge from the crank-case is transferred. It will be noted that the transfer and exhaust ports are both open at the same time, and in order to prevent the fresh charge rushing out through the exhaust port, the top of the piston is specially shaped to deflect and separate the gases as indicated by the arrows. Observe that each downward stroke of the piston is both a power and an exhaust stroke, and that each upward stroke is a compression and induction stroke. As a power stroke occurs every time the piston reaches top dead centre, the magneto must be driven at the same speed as the crankshaft.

Having explained the action of the two systems in use, we can now proceed to a more detailed examination of engines, which will enable the reader to understand better the various processes of adjustment and repair.

The Number of Cylinders.—Most modern motor cars of the four-stroke type have four, six, or eight cylinders, and are water cooled. A few cheap four-stroke-engined cars have two cylinders (usually air-cooled); and most two-stroke engines have only two cylinders. The greater the number of cylinders, the smoother does the engine run.

Usually the cylinders are arranged vertically, but sometimes (usually with eight-cylinder engines), they are arranged in the form of a V, the angle between the cylinders being generally between 45 degrees and 90 degrees. This V arrangement enables the total length of the engine to be kept within reasonable limits. In the case of eight-cylinder engines the big ends of the connecting-rods are forked or pivoted, enabling two rods to work on one crank pin.

Typical Engines Explained in Detail.—Figs. 148 to 152 show constructional details of typical four-cylinder and six-cylinder engines (with their crankshafts) respectively, and perspective views of a modern chassis are given under that heading.

The chief part of the engine, it will be noticed is the cylinder block and the crank-case usually (not always) cast in one block (monobloc), but sometimes consisting of two castings bolted together. Running on bearings in the crank-case is the crankshaft. Two- and four-cylinder engines usually have either a two- or three-bearing crankshaft, whereas six- and eight-cylinder engines may have seven or more bearings. The greater the number of bearings, the less is the tendency for the shaft to whip a bend when it is revolving. The parts of the crankshaft which run in these bearings are called journals, and the parts to which the connecting rods (Fig. 152), are attached are called crank pins, whilst the parts connecting the crank pins to the journals are termed webs. The upper part of the connecting-rod carries the piston to which it is connected by means of a gudgeon pin. Grooves are cut in each piston to receive piston rings which, being slotted (*see* under *Piston*), and therefore flexible, make each piston a gas-tight fit in each cylinder. A bad fit or a worn ring means loss of power. The bore of the cylinder refers to its internal diameter, and the distance travelled inside the cylinder by the piston is called the stroke. The stroke is always twice the throw of the crank.

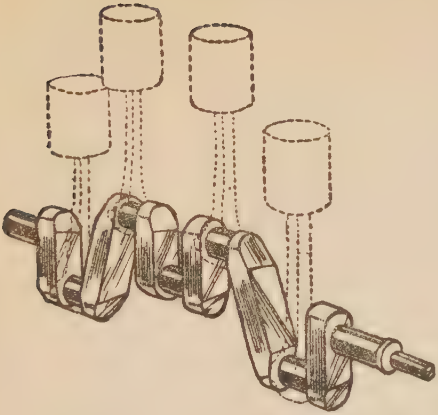


FIG. 149.—The Arrangement of the Cranks in a Four-cylinder Engine (three-bearing crankshaft).

A flywheel is secured to the rear end of the crankshaft to smooth out the intermittent impulses received by it.

We have already seen that each cylinder has only one power stroke in every four, or one power stroke in every two revolutions. A single-cylinder engine would therefore run somewhat jerkily and for that reason two or more cylinders are used. In a two-cylinder engine there is a power stroke for every revolution of the crankshaft; in a four-cylinder engine there are two power strokes for every revolution of the crankshaft; in a six-cylinder engine there are three power strokes per revolution; and in an eight cylinder four power strokes per revolution. Lighter flywheels are used on eight-cylinder engines, because the turning effort is smoother.

Proceeding with the description of typical engines it will be seen that studs are secured in the top of the cylinder, which pass through holes in the cylinder-head. Notice that water openings (forming a water jacket) are cast in the cylinder, and these openings coincide with similar openings in the cylinder-head. Later we shall see how the engine is kept at a reasonable temperature by means of the cooling system. Also situated in the cylinder are the inlet and exhaust valves.

In Fig. 148 which shows a four-cylinder side-valve engine, the path of the exhaust ports is shown by dotted lines. The inlet ports are grouped together into one passage between the two centre cylinders and thence to the carburettor.

Beneath the crank case is the oil sump, the reservoir from which the lubricating system draws its supply. Connected to the front end of the crankshaft is a sprocket driving the magneto by means of a chain (sometimes a gear drive is used), the magneto sprocket containing twice the number of teeth as the crankshaft sprocket. Geared also to the crankshaft is the camshaft, which lifts the valves at regular intervals. Each valve is held on its seating by means of a 40-lb. compression spring, one end of which is secured to the bottom of the valve stem. The valve after being lifted by the cam, is returned to its seating by spring power. The camshaft, as already explained.

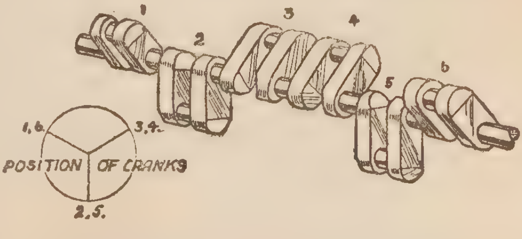


Fig. 150.—Crankshaft of a Six-cylinder Engine. The example shown has seven main bearings.

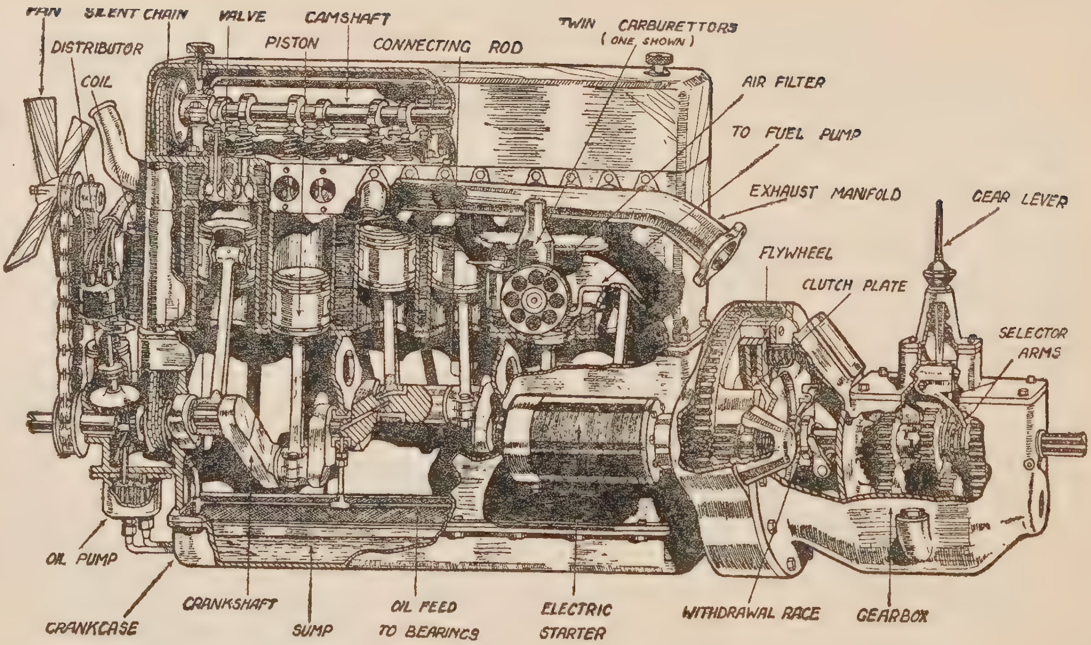

FAN
SILENT CHAIN
VALVE
CAMSHAFT
DISTRIBUTOR
PISTON
CONNECTING ROD
TWIN CARBURETTORS (ONE SHOWN)
COIL
AIR FILTER
TO FUEL PUMP
EXHAUST MANIFOLD
GEAR LEVER
FLYWHEEL
CLUTCH PLATE
SELECTOR ARMS
OIL PUMP
CRANKCASE
CRANKSHAFT
SUMP
OIL FEED TO BEARINGS
ELECTRIC STARTER
WITHDRAWAL RACE
GEARBOX

FIG. 151.—A Modern Power Unit. A Six-cylinder Engine with overhead camshaft driven by silent chain and having coil ignition, twin-balanced carburettors, forced-feed lubrication, etc. The order of firing is 1–4–2, 6–3–5, and No. 1 cylinder is always that nearest the radiator.

is driven at half engine speed, since each valve opens only once in every two crankshaft revolutions.

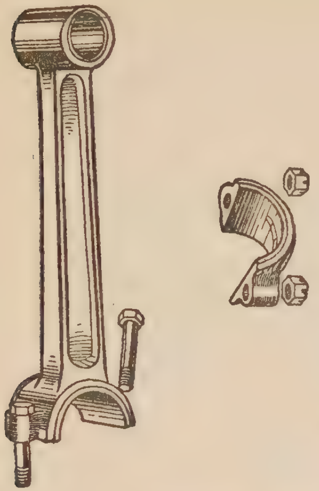


FIG. 152.—A Connecting Rod, showing details of the big end.

Each valve is mushroom headed, and the edges of the valves are conical or bevelled; these edges seat upon similar bevelled edges cut on the valve seating. Such valves are called poppet valves, and with but few exceptions this type is universally adopted. The exceptions are those cars (usually expensive), fitted with sleeve valves, an example being the Daimler and Knight engines.

Bearing on each cam is a tappet and as each cam has a hump or eccentric upon it, when the camshaft revolves it lifts the tappet, the upper end of which, pushing the valve stem, lifts the valve from its seating and enables (in the case of an inlet valve) the gas to enter the cylinder, or (as with the exhaust valve) the burnt gas to escape. When the valve is on its seating there is a slight gap between the head of the tappet and the bottom of the valve stem, to allow for expansion due to the heat generated in the engine. Adjustment is provided to enable this gap to be set after wear. Notice that the camshaft runs parallel to the crankshaft in an engine with side valves. Fig. 153 shows a typical poppet valve, together with its spring, washer, and cotters. The cotters fit into the groove in the stem, and are held there by means of the washer, over which the spring passes. So far we have dealt only with side valves. There are two other valve arrangements in popular use—the overhead valve system operated by push-rods and the overhead valve system operated by overhead camshaft. The three systems are shown in Figs. 154 to 156, together with plans of the combustion chambers. The more usual system of o.h.v. operation is by no means of push-rods and rockers (Fig. 155), actuated by a camshaft situated in the crankcase as with the side-valve engine. This system calls for lengthy push-rods, which tend to bend at high speed and also add to the weight of the valve gear—which for efficiency should be a light as possible.

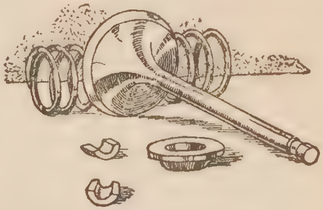
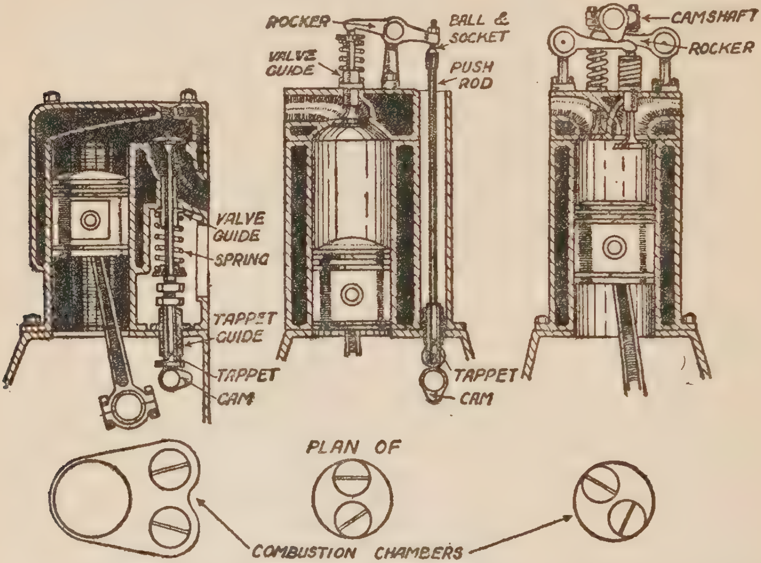


FIG. 153.—Details of the Valve, Spring, Cotters, and Collar.

For these reasons the overhead camshaft was introduced and a glance at Fig. 156 shows how simple the system is. The only disadvantage (not a serious one), is that the o.h.c. needs bevel gears and a vertical shaft, or silent chain (*see* Fig. 151.)



FIGS. 154 to 156.—(*Left to Right*) : Three common types of Valve Gear : Side-by-side, over-head valve (O.H.V.), operated by rocker, and overhead valves (O.H.C.), operated by camshaft.

The sleeve valve consists of a cylinder or sleeve fitted to each cylinder between it and the piston. Ports cut in the cylinder and the sleeve are made to coincide at certain intervals (corresponding to the four strokes of induction, compression, power, and exhaust) by the rotation of the sleeve.

Some cars (those of the high-speed type), are fitted with a supercharger, which device forces the gas into the cylinder under pressure (from 4 lb. to 10 lb. per sq. in.) ; normally, of course, it enters at atmospheric pressure only. The supercharger usually takes the form of a Roots blower. It is generally situated between the carburettor and the engine. (See *Valves* and *Superchargers*)

The Silencer and Exhaust System.—Secured to the cylinder block immediately over the exhaust ports is the exhaust manifold into which the exhaust gases pass, and from thence into a pipe to which a silencer is attached. The exhaust gases are at a fairly high temperature and under high pressure and the silencer enables them to cool and expand before being expelled into the air. By this means the noise of the exhaust is considerably reduced.

A further inspection of Fig. 151 shows the electric starter motor, on the shaft of which is a pinion. When the starter button is pressed, centrifugal force throws the pinion into gear with the teeth on the flywheel, so rotating the engine. Directly the engine starts, the pinion is thrown out of gear. This pinion arrangement is known as a Bendix, and it is free to move on a quick-pitch thread cut on the armature shaft. When the starter motor is in operation this thread draws the pinion into engagement with the teeth. When the engine is running, this thread throws the pinion out of engagement (*see* Fig. 157).

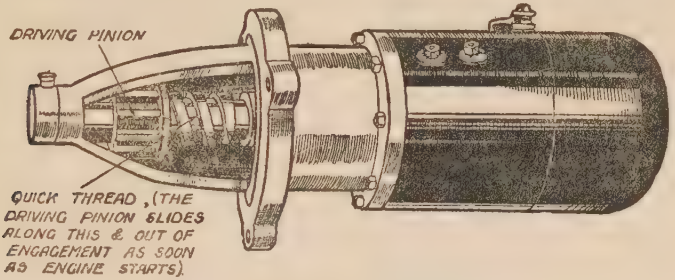

DRIVING PINION
QUICK THREAD, (THE DRIVING PINION SLIDES ALONG THIS & OUT OF ENGAGEMENT AS SOON AS ENGINE STARTS).

FIG. 157.—A Typical Electric Starter.

The dynamo which charges the battery is also driven by the engine.

The Clutch and Gearbox.—Interposed between the engine and the gearbox is the clutch, which is a device enabling the engine to be disconnected from the gearbox. Such a device is necessary for gear-changing, and also to enable the engine to be hand-started. The gearbox provides a means of varying the ratio between the engine revolutions and the rate of revolution of the rear wheels. It is also possible to disconnect the engine from the transmission by placing the gear lever in the neutral position. Most cars have either three or four forward speeds and one reverse gear.

Connecting the gearbox with the axle are shafts with flexible joints. Sometimes also flexibly coupled joints connect the clutch and gearbox. In the former case the shaft is called a propeller shaft, and in the latter a clutch shaft. We can now deal briefly with these three parts of the transmission. (See *Clutch* and *Gearbox*).

The Clutch.—The most popular clutch is undoubtedly the single-plate type, and although multi-plate clutches are used in the more highly-powered cars, this explanation is unaffected by them; the basic principles are practically the same, the chief difference being in the clutch withdrawal mechanism.

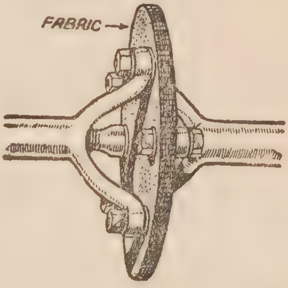


FIG. 158.—One of the modern types of Universal Joint, the Fabric or Hardy disc.

The single plate of the clutch has an annular ring of specially woven fabric riveted to each side of its periphery (*see* Figs. 159 and 160). One fabric disc bears or presses

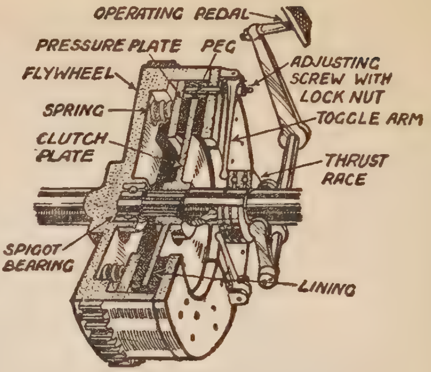

OPERATING PEDAL
PRESSURE PLATE
PEG
FLYWHEEL
ADJUSTING SCREW WITH LOCK NUT
SPRING
TOGGLE ARM
CLUTCH PLATE
THRUST RACE
SPIGOT BEARING
LINING

Fig. 160.—A Cut-away of a Single-plate Clutch, as used mostly on light cars.

against a surface machined on the flywheel, and the other bears against a pressure plate. This clutch plate can slide on a short shaft connected to the gearbox and the clutch completed is entirely encased in a housing attached to the flywheel. Interposed between the pressure plate and the clutch housing are a number of springs varying from three to six, which force the single plate into contact with the flywheel. It will readily be perceived, therefore, that the two fabric discs are gripped under spring pressure between the pressure plate and the flywheel. The drive to the gearbox is therefore by friction.

Now, what happens when the driver presses on the clutch pedal? As will be seen from Figs. 159 and 160, the pressure plate is forced backwards, compressing the springs and thereby releasing pressure on the clutch plate.

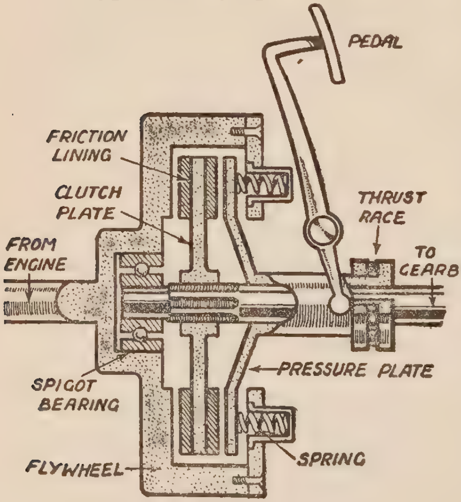

PEDAL
FRICTION LINING
CLUTCH PLATE
THRUST RACE
FROM ENGINE
TO GEARBOX
PRESSURE PLATE
SPIGOT BEARING
SPRING
FLYWHEEL

Fig. 159.—Showing how a Clutch works. The withdrawal mechanism varies with different makes.

This type of single-plate clutch is that generally employed; but sometimes only one central spring is employed, yet the principle is the same. In another design of clutch (Fig. 161), two cones, male and female, form the driving surface.

The interior of the flywheel is the female cone, and the male cone is formed on a plate secured to the gearbox shaft; the latter is lined with a friction drive material. A single spring maintains the two cones in contact.

The multi-plate clutch consists of a number of phosphor bronze and steel plates alternately arranged. The bronze plates rotate with the flywheel and the steel plates rotate with the clutchshaft. Normally they are pressed together by a number of concentrically-arranged springs, and in that position they transmit the drive. The withdrawal mechanism is somewhat similar to the single-plate clutch. Multi-plate clutches run in oil.

The Gearbox.—A three-speed gearbox will be dealt with for purposes of explanation. Fig. 162 shows an internal view of a gearbox, with the names of the various parts attached. The jackshaft and mainshaft are not one continuous shaft, but the end of the mainshaft is free to revolve inside the jackshaft. In Figs. 165 to 167 which show how the various gears are obtained the spigot bearing is omitted for clarity, the continuation of the mainshaft being shown by the dotted lines. Above Fig. 162 is a plan-view of the gear lever showing its various positions.

It will be seen that, in the top gear position, the drive is direct to the rear axle, no intermediate variation in drive ratio being introduced by the gearbox. The gearbox just dealt with is of the sliding gear type, with straight cut or spur gears. Modern gearboxes especially four-speed ones, are of the constant mesh type, employing single- and double-helical gears, as shown in Fig. 168. The letter references in Figs. 165 to 167 will enable the reader to trace the various gears through.

The jackshaft (Fig. 167), is connected to the engine via the clutchshaft. The mainshaft is in line with the jackshaft but free to revolve independently. The mainshaft is spliced or grooved, and has mounted on it two gears which can slide along but must turn with it. The layshaft is geared to the jackshaft and always revolves with it, and this layshaft carries additional gears. When the gear lever is moved the selectors slide appropriate gears into mesh.

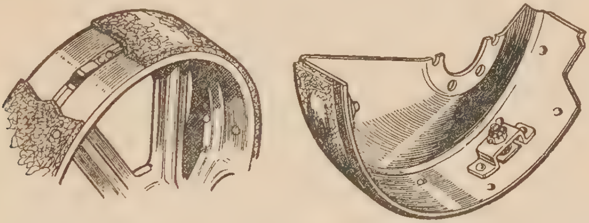


FIG. 161.—The Cone Clutch and its parts.

The Propeller Shaft.—As already stated, the propeller shaft conveys or transmits the power to the back axle. Now the back axle is mounted upon springs, and it is in frequent movement due to inequalities in the surface of the road, and therefore some method of allowing for movement of the propeller shaft in an up-and-down direction must be introduced. The device incorporated for this purpose is the universal joint, of which there are many types. That usually adopted is the fabric disc (Fig. 158). To each shaft connected by a disc is a three-armed forging or spider, which is bolted to the fabric disc. It is an entirely satisfactory method of coupling, for it has no moving parts and cannot therefore wear, it is silent and entirely double free.

Other types of universal joint are the hook, the slotted ball, the sliding block and the ring. We have now obtained a sort of bird's-eye view of the engine clutch and gearbox and so we arrive at the final part of the transmission—the back axle.

The Back Axle.—The back axle contains the mechanism by means of which the power is transmitted to the wheels—the differential gear. A glance at Fig. 169 will show that it consists of the axle tube or casing, two axle shafts, and the differential gear itself. In place of the bevel pinion and crown wheel shown, some cars have a worm and worm wheel; but the principle is exactly the same. The differential gear enables one wheel (the outer wheel) to revolve faster than the other when turning a corner or swerving. This is very necessary, for without it steering would be difficult, and the tyre might be ripped off the wheel when turning a corner. Skids would also result.

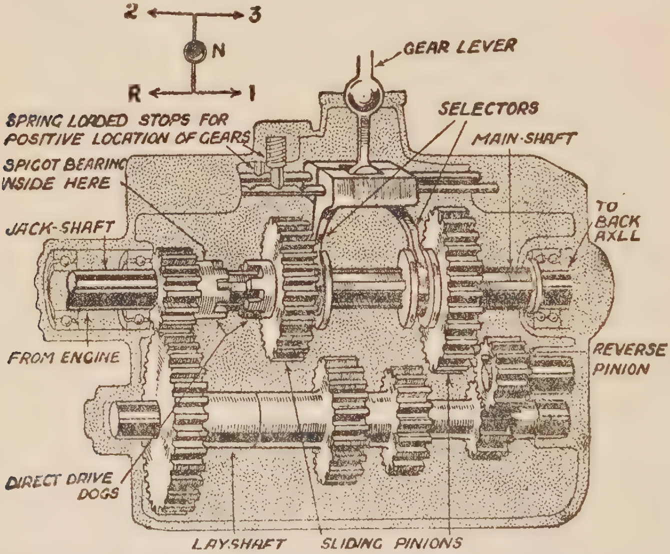

2
3
N
R
1
GEAR LEVER
SPRING LOADED STOPS FOR POSITIVE LOCATION OF GEARS
SELECTORS
MAIN-SHAFT
SPICOT BEARING INSIDE HERE
JACK-SHAFT
TO BACK AXLE
FROM ENGINE
REVERSE PINION
DIRECT DRIVE DOGS
LAYSHAFT
SLIDING PINIONS

Fig. 162.—The principal parts of a typical three-speed gearbox. The gears are shown in the neutral position. The jackshaft and mainshaft are not one continuous shaft, but the end of the main shaft is free to revolve inside the jackshaft.

How the Differential Gear Works.—The differential gear comes into play directly the car deviates from the straight or if one rear tyre is slightly deflated and, therefore, of a smaller diameter. Fig. 170 shows the action in diagrammatic form. A and B are bevel gear wheels connected to each rear half-axle shaft, whereas C and D rotate with the differential cage contained inside the crown wheel. When the bevel pinion drives the crown wheel, the two shafts A-B connected to the rear wheels will revolve at an equal speed provided the car is driven in a straight line, and the bevels, cage and crown wheel will revolve as a solid mechanism just as if the two shafts A and B were joined together. The driving forces are balanced. Directly the car deviates from a straight line, however, the bevels rotate on their shafts, as well as rotating bodily, and so the wheels, although positively driven, are enabled to rotate at independent speeds. This can be easily verified by jacking up the back wheels and spinning one of them. The other wheel will revolve in the opposite direction. If only one rear wheel be jacked up, the engine may be started and any gear engaged, yet the jacked-up wheel only will revolve. (See also *Back Axle* and *Differential*.)

Having described how the engine works it is necessary to deal with the subsidiary units—the ignition system, the carburettor, and the cooling and lubricating systems. For more detailed explanations see also under their respective headings.

The Cooling System.—The heat generated by combustion would rapidly make the engine so hot that the bearings and pistons would seize, the white metal in the bearings would melt, and the whole engine would cease to work, were not methods of lubricating the moving parts and keeping them at a reasonable temperature adopted. Actually two systems co-operate to bring about this desirable state—the cooling system and the lubricating system. Both are of equal importance. A few cars to-day are air-cooled and in such cases fins are formed on the cylinders which dissipate the heat. Most motor-cycle engines are air-cooled. Nearly every car, however, is cooled by a water-circulating system. There are two such systems—the thermo-syphon system (Fig. 172), which is automatic and the pump system, in

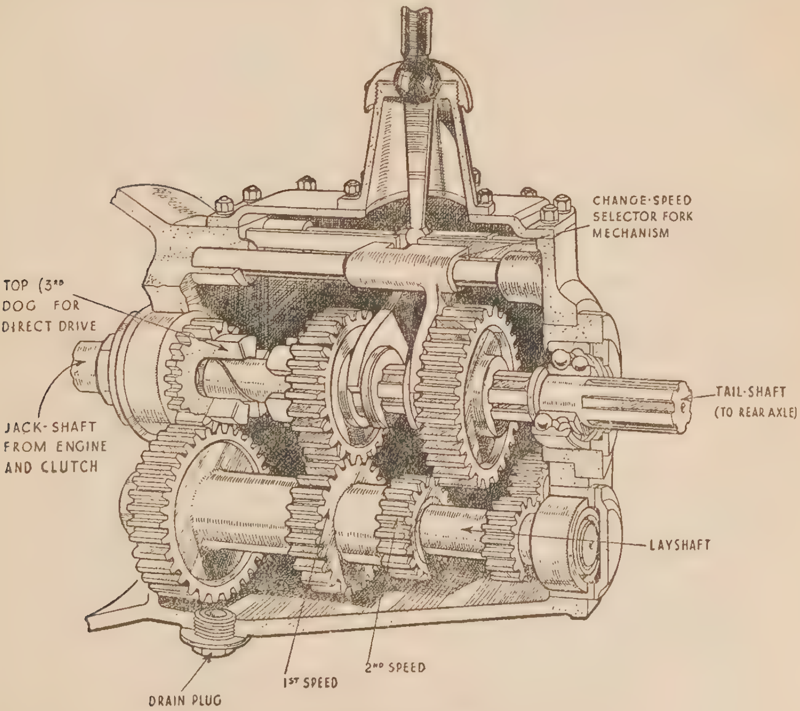

CHANGE-SPEED SELECTOR FORK MECHANISM
TOP (3RD DOG FOR DIRECT DRIVE
JACK-SHAFT FROM ENGINE AND CLUTCH
TAIL-SHAFT (TO REAR AXLE)
LAYSHAFT
2ND SPEED
1ST SPEED
DRAIN PLUG

Fig. 163.—Another internal view of a Gearbox.

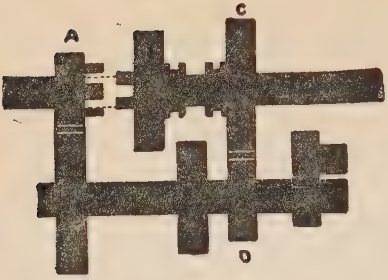


FIG. 164.—The first speed ABDC.

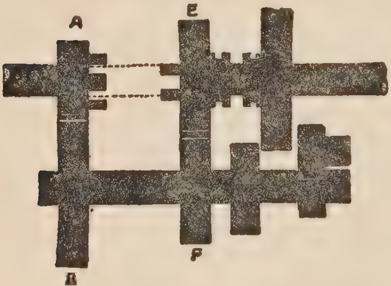


FIG. 165.—The second speed ABFE.

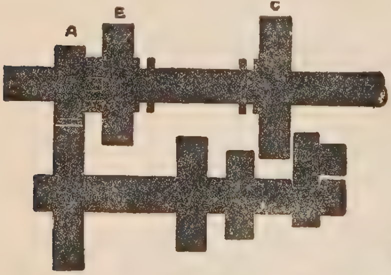


FIG. 166.—The third or top speed AEC.

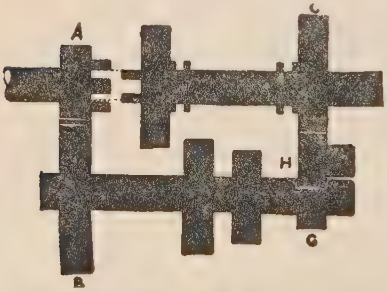


FIG. 167.—The reverse gear ABGHC.

which a mechanically-operated pump keeps the water in circulation (Fig. 173).

The Thermo-Syphon System.—The thermo-syphon system of cooling is fitted to most of the cheaper makes of car, and it is almost trouble-free. We have already seen that water spaces or jackets are formed in the cylinders and cylinder head, and we may now observe from Fig. 172 the complete thermo syphon cooling system. This consists of the radiator, at the top and bottom of which is a pipe coupled by a short piece of rubber hose to the cylinder-head and the bottom of the cylinder-block. A small reservoir tank is situated at the top of the radiator. The radiator may be one of two types, the tubular and the honeycomb, usually the former, which consists of a great number of horizontal tubes, presenting the maximum amount of cooling surface to the air. The copper tube type consists of a number of vertical tubes, having metal fins attached to each by means of which the heat is conducted away from the water

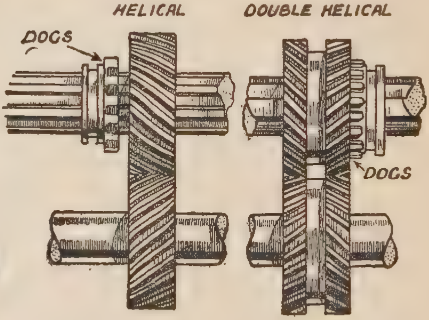


FIG. 168.—Examples of Helical and Double Helical Gears as used on modern Three-Speed Boxes. Both types are in constant mesh. One pinion is fixed to its shaft, and the other rotates freely until secured by a sliding dog. The "silent third" boxes employ this type of pinion.

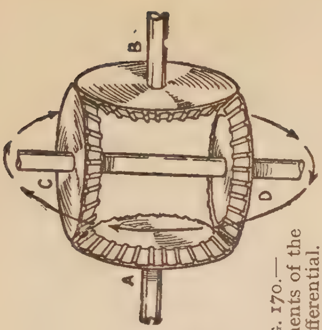


Fig. 170.—Elements of the Differential.

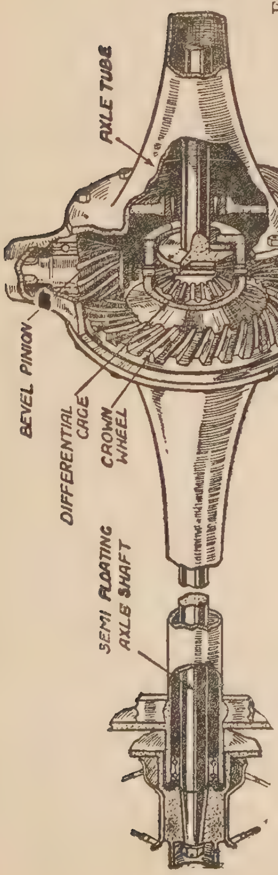


Fig. 169.—The Back Axle showing a spiral bevel drive and differential gear.

in them. The thermo-syphon-system is based on the well-known fact that water expands when heated. It naturally follows that when the water in the cylinder head and the jackets surrounding the cylinders becomes hot, it will rise up the pipe leading to the top of the radiator, where it commences to cool and descend down the radiator tubes and so via the bottom or water pipe back to the cylinder-block. This action is continuous. Nearly all cars to-day are provided with a fan; for whilst the movement of the car will force sufficient air past the radiator to cool the water in it, when the car is stationary, or when its speed is reduced (as in traffic or when climbing a hill), the fan will maintain a flow of air through the radiator and prevent over-heating. The fan is usually driven from a pulley fixed to the crankshaft, and when an engine tends to run on the cool side, the removal of the belt will often effect a cure. (See also *Cooling System.*)

The Pump Water-Circulating System.—When a water pump is employed it is usually of the centrifugal type (Fig. 171) gear driven from some convenient part of the engine; it forces the water through the radiator and so to the cylinders. In this system it is obvious that the speed of the water in circulation depends absolutely on the speed of the engine and not, as in the thermo-syphon system, on difference in temperature between the hot and the cold water.

Thermo-Static Control of Engine Temperature.—I have already indicated how important it is that the engine should not get too hot. It is now necessary to say that it should not be allowed to run too cool; for the temperature best suited to the efficient working of

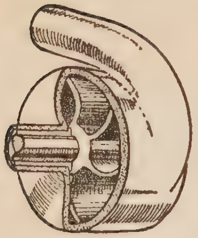


FIG. 171.—A typical Water Pump.

a petrol engine is just under boiling point. This well-known fact has brought into existence a number of heat-operated devices known as thermostats. Not all cars are fitted with them; but within a few years every car will have such a device. Its action, briefly, is this: a diaphragm is deflected by the water temperature in such manner that the cool water is kept in the radiator and isolated from the cylinder until the engine temperature is increased, when the diaphragm relaxes and permits the normal circulating system to operate. Such a device keeps the engine at a constant temperature (Fig. 173).

A later development of this idea is the thermostatically-controlled radiator shutter. In this device a series of vertical or horizontal vanes in front of the radiator, each pivoted to allow of movement, are operated by the thermostat. Dashboard-controlled radiator shutters are also sometimes fitted.

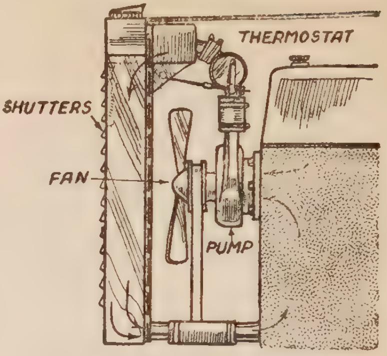


FIG. 173.—A Pump System with thermostatically controlled radiator shutters.

The Lubricating System.—No reader of this book needs to be told that his engine must have a proper supply of oil. He knows that the dipstick is there to guide him as to the exact amount of oil in the sump. He may not be so clear, however, about what happens to the oil once it is poured in. Lubricating systems as fitted to cars function on one of three principles. The orthodox system is that in which oil is poured into the sump, the average quantity (with the dipstick showing "full") being from 1 to 1½ gallons. Inside the sump is the oil pump (*see* Fig. 174), which forces oil to the bearings as indicated by the arrows.

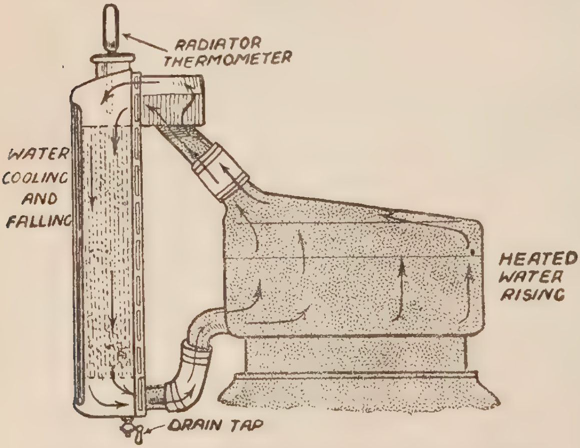


FIG. 172.—Diagram showing how the Thermo-Syphon System works.

It will be noted that the crankshaft is drilled, so that oil may be conducted to the journal bearings and the big ends. The pump is usually driven by gears from the camshaft, and it draws the oil first through a filter and then delivers it to the main bearings via pipes. From thence the oil passes through the ducts in the crankshaft, lubricating the big ends. The revolving crankshaft aided sometimes by dippers fitted to the big ends, churns up the oil in the crank-case into a fine mist, which lubricates the camshaft, tappets, pistons, cylinder, and gudgeon pins. With o.h.v. engines pipes are also led to the valve rockers and valve gear. The oil-gauge is fitted to the dash-board, and if it records a pressure of from 5 lb. upwards per square inch, it is functioning satisfactory.

The Dry Sump System.—This term really explains itself. The sump contains no oil, which is placed in a separate reservoir, from which a delivery pump conducts it to all main bearings, whilst another pump collects the oil as it drains into the sump and returns it to the reservoir.

The Flywheel Oil Circulating System.—In this third system the oil is circulated by the flywheel; the periphery of this slings the oil (in which it is partly immersed), into a reservoir, from which the oil falls by gravity to the various bearings.

The pumps employed for oil circulation are usually of the plunger or rotary type; they very seldom go wrong. (See *Engine Lubrication*).

Chassis Lubrication.—Most of the chassis bearing points, such as the shackles and steering pins, are lubricated nowadays by a grease gun or pistol, which, applied to the various nipples fixed to the various lubrication points, enables grease or oil to be forced under high pressure to the bearing surfaces. Not only does the gun force new lubricant in; it also forces the old and dirty lubricant out. Other parts, such as the hubs and the springs, require somewhat old-fashioned methods to be detailed with later.

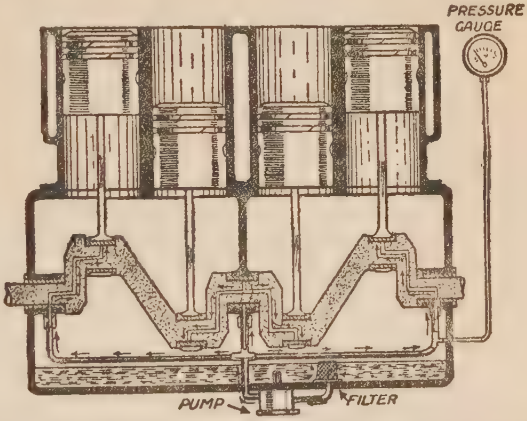


FIG. 174.—Showing the arrangement of a Forced Feed Lubrication System. The arrows indicate the direction of the oil flow.

The gearbox and back axle have filler plugs and oil level plugs, and oil is merely poured in to the required level.

The "One Shot" Chassis Lubricating System.—More expensive cars are fitted with the "one shot" lubrication system, by means of which the whole of the chassis lubrication points are fed with lubricant with a few strokes of a plunger operated by the toe from the driver's seat. The general arrangement of this system is shown in Fig. 175. (See also *Chassis*.)

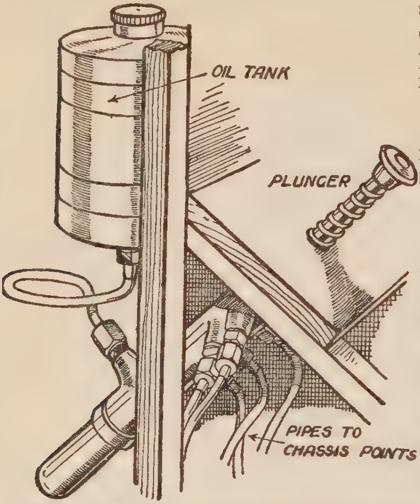


FIG. 175.—The "Heart" of the One-shot System of Chassis Lubrication.

FOUR-WHEEL SKID. — Name given to describe a rare condition in which a car slides on its four wheels to the right or to the left. It is also known as a "Front-wheel skid."

FRACTIONAL DISTILLATION. —The process of separating a mixture of liquids into its components by distillation and by separately collecting the various components or "fractions" as they distil over.

Petrol and other motor spirits are all obtained by processes of fractional distillation.

FRACTIONATION.—The process of fractional distillation, which see.

FRAME.—A term which in motor engineering usually refers to the light frame of steel upon which the car is erected.

FRENCH CHALK. — Genuine French chalk is a species of steatite which has been very finely ground. It possesses lubricating properties. Being non-adhesive, it will prevent sticking between parts. On account of this property, it is largely used in puncture-repairing and general tyre manipulation.

See *Steatite*.

FRICTION.—The resistance offered to a moving body by the surface over which it moves.

In any mechanical device it is impossible to eliminate friction. Nevertheless, in many respects, the working efficiency of the machine is governed by the degree to which the friction of its parts is lessened.

FRICTION DRIVE.—A form of friction gear used in some light cars. This form of gear dispenses with the ordinary type of gearbox-clutch assembly and substitutes for it an arrangement of friction discs making variable contact with the flywheel from which the drive is taken.

FRICTION LOSS.—In a car this is the difference between the power produced by the engine and the power available at the road wheels, to which computation must be added the friction loss in the engine itself.

FRONT - WHEEL SKID. — See *Four-Wheel skid.*

FROUDE WATER-BRAKE.—An apparatus for the estimation of the developed horse-power of an engine which functions by causing the engine-power to be absorbed in a hydraulic braking system.

FUEL DOPES.—Name applied to a number of substances which are added to the fuel of a car in order to increase the engine-power produced by it or to effect an economy in fuel consumption.

The commonest fuel dope is naphthalene, a white crystalline substance obtained from coal-tar. Its efficiency in this respect is sometimes disputed.

FUEL FEED PUMPS.—Methods of petrol feed have changed in recent years. In the old days a simple gravity feed was used on most cars, though some of the more expensive ones were fitted with a pressure system. With some pressure feeds the air supply was pumped into the tank by hand, in others by a mechanical pump, and there was another type which relied on exhaust pressure for its efficiency. All pressure systems have the objection that, should an air leak occur, the petrol will not feed to the carburettor. This disadvantage produced the vacuum system which, though it caused much trouble when first marketed, became very reliable and was in general use until quite recently.

In the most up-to-date cars petrol is fed to the carburettor by a pump, of which there are two types. One is purely mechanically operated, while the other is operated electrically. These pumps have supplied the demand for a system suitably to feed a down-draught carburettor. This type of carburettor is fitted high up under the bonnet, and thus any form of gravity feed is out of the question. A rear tank is considered safer in case of accident, and a pump can feed from this position without difficulty. Further, with a pump feed the flow of petrol ceases as soon as the engine is switched off, and it is not therefore possible to lose a quantity of petrol, (which may leak on to the road under the car), by a flooding float chamber.

Though the electric petrol pump may appear to be a complicated instrument, it is actually very simple and causes very little trouble in use. The current consumption is very small indeed, being less than

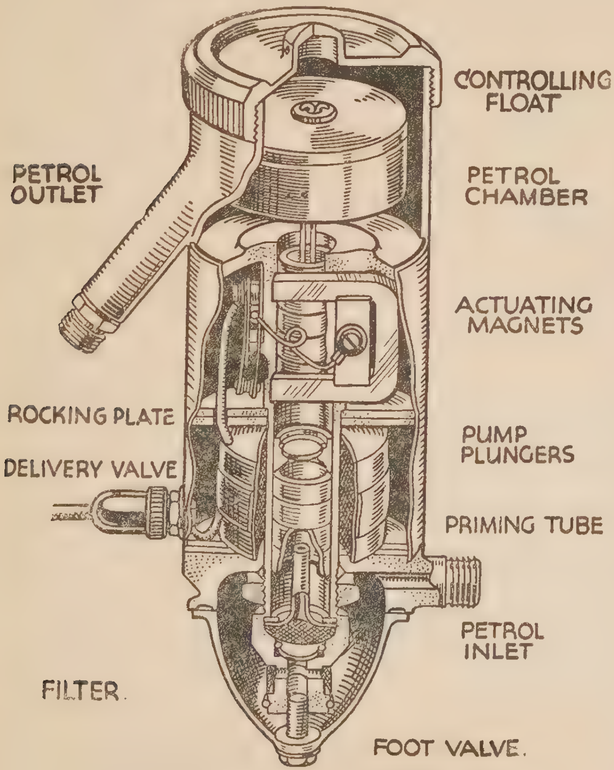


Fig. 176.—The internal parts of the Petrolift pump.

that required for a single side lamp. At the same time it is very efficient, and does not need any priming should the rear tank be allowed to run dry.

The pump itself consists of a metal container, an electro-magnet, and a contact breaker to control the current, and therefore the periods when the magnet is active. A filter is contained in the base of the housing, and this can be removed for cleaning by taking out the securing bolt.

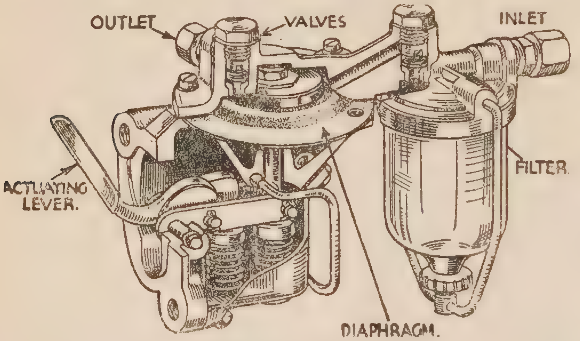


Fig. 177.—The well-known camshaft-operated A.C. mechanical fuel pump.

Electro-Magnetic Action.—When the current is switched on by the ignition switch the contact-breaker points are closed, and the electro-magnet becomes active or magnetised. This in turn pulls the diaphragm to itself, thus causing a vacuum in the pump. This vacuum draws up petrol from the tank. The movement of the diaphragm, however, breaks the circuit, and it is returned to its original position, thus propelling the petrol into the float chamber which is situated in the top of the instrument. The petrol cannot be returned to the float chamber by this action as there is a small non-return valve at the petrol inlet. Having completed the movement, the circuit is "made" again and the process is repeated. In the float chamber at the top of the pump is a float. When enough petrol has been pumped up, the float automatically cuts off the current until the level falls again. Thus enough petrol is always available for the engine's requirements, but there is no chance of flooding the carburettor by excessive activity of the pump.

Any repairs required by an electric petrol pump are best carried out by the service station, but before the pump is dismantled it should be ascertained that current is reaching it. To make this test, the ignition should be switched on and the lead disconnected at the pump. Now, if this lead is shorted on some metal part of the car a spark should occur. If none occurs, then the trouble is in the wiring or connections, and these should be investigated. If the current is present and a light tap on the pump body with a screw-driver handle does not put matters right, the services of an expert are required.

Cam-operated Pumps. — The mechanical pump works on much the same principle, but the diaphragm is operated by a rocker-arm which bears on a cam on the camshaft of the engine. The petrol is fed from the tank through a glass bowl type of filter. When the diaphragm is operated it causes a vacuum which draws up the petrol from the tank. On the opposite stroke this diaphragm forces the petrol through the outlet pipe to the float chamber of the carburettor. A non-return valve on the inlet side prevents it being forced back to the petrol tank. When petrol in the float chamber has reached the proper level the usual valve cuts off further supplies. The pump continues operations until the pressure on the top of the diaphragm, due to the petrol collected there, becomes very high. The diaphragm is thus kept depressed. The rocker arm is made in two pieces, and the inner piece becomes stationary while the outer one continues to operate. As soon as the level in the float chamber drops, more petrol is fed from the pump and the pressure therefore drops. The two parts of the rocker become connected again and the cycle starts afresh.

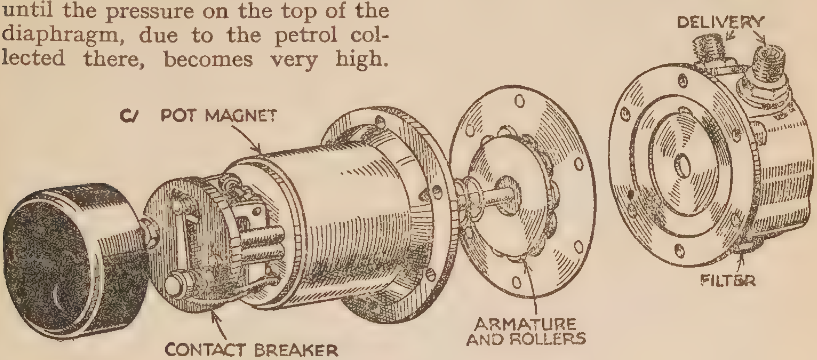


FIG. 178.—An electrically operated fuel pump.

Points to Watch.—Mechanical pumps are very reliable in use. It is necessary that the glass filter bowl, which is on the suction side of the system, should be fitted carefully so as to prevent any air leaks. The two valves, one on the suction side and one on the delivery side, are accessible by removing the plugs which are fitted over them. Should they be held off their seatings by grit, the pump will not operate. The valves are small discs of a special fibre, and it should be noted when cleaning them that the polished side of the disc should be fitted downwards against the seat of the valve. The valve can also become faulty should this small disc not be perfectly flat. No attempt should be made to straighten a disc with a file or otherwise, but a new one should be obtained. The plugs should be securely replaced.

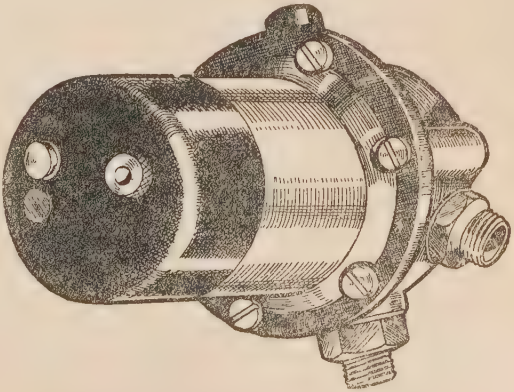


FIG. 179.—Another type of fuel pump.

FUEL SUPPLY SYSTEMS. — The petrol supply system consists of two units: the carburettor and the petrol tank. The petrol may be supplied to the carburettor by gravity feed from the petrol tank, in which case the tank must be near to, and above the carburettor; by force feed from a tank situated at the rear of the car, or by means of the autovac system, which consists of a combination of the gravity and force feed systems. These latter systems are gaining in favour, for they permit of lower body design, and they enable the tank to be placed where the risk of fire is at a minimum.

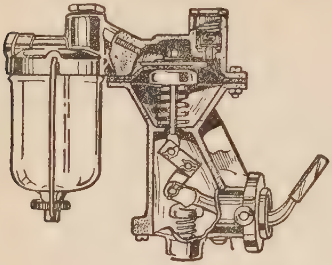


FIG. 180.—An A.C. Fuel Pump.

The Autovac System.—The Autovac system, consists, briefly, of a small tank mounted on the front of the dash, supplying petrol to the carburettor by gravity flow, and a pipe fixed to the carburettor induction pipe, is also connected to the top of this small auxiliary tank. Another pipe connects this tank with the main tank at the rear end of the car. It will be seen, therefore, that when the engine is running petrol will be drawn by engine suction from the main tank to the auxiliary or vacuum tank. A float is fitted inside the latter, which cuts off the supply from the main tank as soon as the desired level is reached in the small tank. The system is certain and automatic in action (*see* Fig. 181).

Fuel Pump Supply System.—In the force feed system a small hand-pump is operated to raise the air pressure over the petrol in the main tank, thereby forcing it along the supply pipe to the carburettor. This method is rarely used except for racing purposes. The pressure (a gauge must be fitted to the dashboard), is usually between 2 and 3 lb. per square inch.

A more satisfactory method than the hand-pump is the mechanically-operated fuel pump worked by a special cam on the engine camshaft. Of these the A.C. is most popular (*see* Figs. 177 and 180). Projecting from the pump into the crank-case is a finger which is lifted up and down by the pump cam. This operates a fabric diaphragm, and a special mechanism keeps the supply pressure constant, as explained earlier.

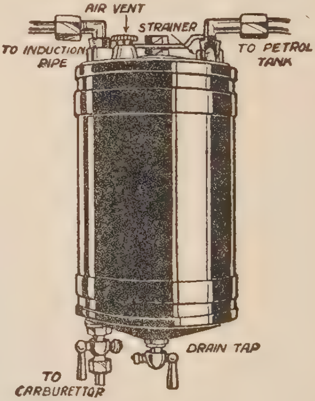


FIG. 181.—The Autovac. Drain off occasionally any sediment from the drain tap. Also clean the strainer every month. The holes in the air vent must be clear.

The Carburettor.—The purpose of the carburettor is to supply a correct mixture of petrol and air to the engine. To do this it has to measure the quantity of air passing, simultaneously measuring the correct amount of petrol. Reduced to its simplest terms, a carburettor consists of a small reservoir connected with the main petrol supply, and provided with a taper needle valve controlled by a float, which cuts off the supply when the petrol has reached a certain level. The float chamber is connected with a jet which protrudes into the throat of the choke tube or Venturi tube. Air is drawn past this jet by the pistons ; owing to the fall in pressure, due to the reduced diameter inside the choke, petrol is sucked from the jet. The size of this jet is important ; it should not be tinkered with. Situated in the carburettor is the throttle, which is controlled by the accelerator pedal. The carburettor also incorporates a special slow-running tube, and a compensator jet. Some makes have multiple jets (*see* under *Carburettors*). Most carburettors to-day are fitted in such a manner that the gas is heated before it enters the cylinder. This is usually arranged by causing the exhaust gases to pass round some part of the induction pipe. Such an arrangement is known as the " hot spot " and it considerably aids carburation, causing a more complete atomisation of the fuel before it enters the combustion chamber. Fig. 182 shows a simple carburettor, which will make its principles clear.

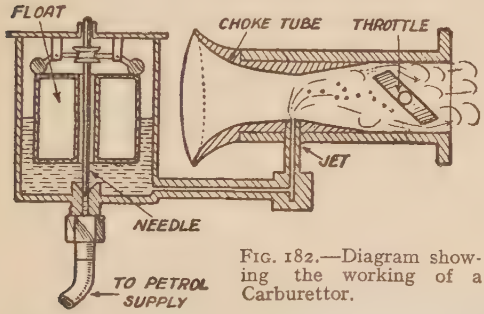


Fig. 182.—Diagram showing the working of a Carburettor.

Having now obtained a general idea of the various parts and their functions for further information on the various parts consult each under its separate heading.

FUEL GAUGE.—A gauge fitted to a petrol-tank in order to determine the quantity of fuel within the tank at any given time.

The best known fuel gauge is of the float type in which a float arrangement operates an indicator on a dial secured to the filler-cap of the tank.

Other types of fuel gauges are used from time to time.

FULL-FLOATING AXLE.—See *Floating Axle.*

FUNNEL.—A wide-mouthed vessel of round or rectangular cross-section tapering to a narrow opening at the bottom. Used for pouring liquids into tanks, etc. Occasionally known as a *tundish.*

FUSE.—A protecting device, consisting of a short length of easily-fusible wire, suitably mounted and enclosed, which, being included in an electrical circuit, serves to protect the latter or any portion of it from suffering damage from a temporary excess of current.

G

GAP.—Term which usually designates the spark gap at the plug electrodes. (See *Spark Gap.*)

GAP GAUGE.—A name usually given to a small metal slip having an end of known thickness which is passed between the contact-points of a magneto in order to determine their correct distance apart.

GARAGE.—This should exceed the width of the car by two feet, and the length by three feet. If the length cannot be spared the width should be increased if possible.

The Floor.—The garage should have a substantial floor and concrete will be found the most suitable. It should have a very slight fall from back to front. One in fifty is a suitable grade. Brick walls are best but expensive. Corrugated iron is very cold in winter and hot in summer—both objectionable from the point of view of efficient car storage. Walls made of fireproof composition sheets are suitable but they are brittle and easily broken into.

Perhaps the best garage is the wooden building built up on three inch posts and three inch by four inch rails laid horizontally but with three-quarter inch boarding nailed on; and the whole treated with fireproof composition, or soaking before painting.

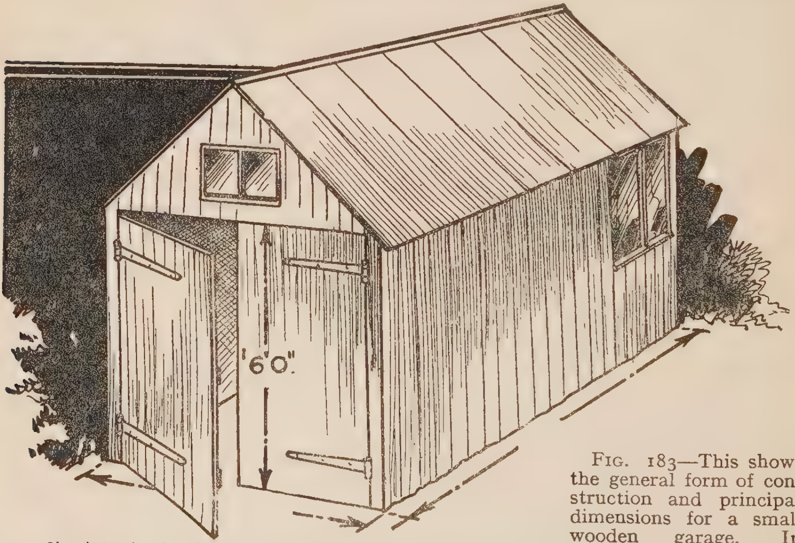


FIG. 183—This shows the general form of construction and principal dimensions for a small wooden garage. In some districts, it should be noted, local councils' requirements must be complied with. Some insist on fireproof construction; all designs have to be submitted for approval before construction is commenced.

Fig. 183 gives an idea of the garage for the moderate sized car. Two doors, meeting in the middle should be provided with top and bottom bolts and a good outside hasp and padlock straps: the hasp and strap being bolted through the doors with round-headed bolts and the nuts inside and the heads in squares in the hasp and strap. The long strap hinges should be similarly bolted through with round-headed bolts with the round heads outside. A window should be in the rear end either in the side wall or the end wall. Generally the end wall is obstructed and a window at one side or the other is more convenient. At the end should be arranged a bench It should be, if possible the full width of the garage or, if space for a tool cupboard is desired, the bench may be four feet long and a cupboard two feet wide and five feet high with a shelf above and hanging hooks provided inside.

The Bench.—The bench should have a front board 10 ins. wide and 2 ins. thick and back boards 1 in. thick to the wall. The width of the bench may conveniently be 1 ft. 9 ins. and it should rest on cross members from a front rail to a rear rail nailed to the posts of the building. The bench legs should be at two feet intervals so there will be three legs in the front, the front rail being halved into them. The legs should be stayed by rails to the back or can be cemented in the floor—the strongest method. A vice may be fitted above one leg preferably the left leg if the bench is on the right of the end wall. The roof should be whitened inside and the wall painted white. Any colour to taste will do for the outside but previously it should have a couple of coats of red lead paint and the lower members of the framing should be creosoted before building up.

Landlord's Fixture.—If the building is laid in the cement floor, it will become a landlord's fixture and must be left if the tenant leaves the premises. Although built and paid for by the tenant it becomes the property of the landlord. A more temporary garage with its own self-contained floor and mounted on four small wide iron wheels may be a tenant's fixture and may be removed by him, but it must not be attached to the ground and must stand independently of any building.

Wash.—In front of the garage the cement floor should be extended to outside in the form of a concrete wash. This may well be 7 ft. wide and 12 ft. long. A small wash is a nuisance. It should have a drain grate and trap in the centre if possible and should slope from all directions towards the drain. Water should be laid on and a hose provided. The hose should have an adjustable nozzle so that a strong jet or a full slow stream of water may be directed on the car. It should be of such a length that every part of the car can be reached comfortably when on the centre of the wash, and should be of the armoured variety which lasts much longer than the plain type.

Lighting.—For most purposes of day-time use, the window at the side and the open doors and a light above the doors as shown will give all the light which may be required. But very often it is important to have light at night and the best method is to have electric light. This can generally be arranged as a branch of the house-lighting; a double lead-covered cable being laid between the house and the garage. It is a safety precaution to have a switch on this line inside the dwelling house so that current may be cut off entirely from the garage. A lamp over the bench, one over the front of the car with a long flex (so that work on the engine can be done) and a wall plug so that a flex and an inspection lamp may be used anywhere, will complete the electric lighting arrangements. If no electric current is available a car battery can be used of the same voltage as that on the car and wired up to bulbs of the right capacity. This battery may be put on a shelf and wired up for charging from the dynamo of the engine, a lead being available—one for earth on the chassis and the other for the terminal which will be disconnected from the car wiring. Or the battery can be charged by the local garage or even put into the car, and the two alternated on garage and car service.

For a fairly large car that is 12 ft. long overall and 5 ft. wide, the garage should be about 18 ft. long inside and 13 ft. wide to allow space for a bench at one side and the specified room all round. If the car be driven into the building towards one side when it is intended to work at the bench, the overall width need not be so great as that suggested. But often the owner-driver is obliged to work first at one side of the car, then at the other, and then at the bench. So the dimensions specified are desirable if not essential.

Features of Construction.—In the case of a garage that will face the public road and be separate from the house alongside, a good plan is to have double doors at both ends and to have a washing place beyond the inner end. For it is better to have a " wash " out of sight of the public road than to be dependent upon the garage front approach or the inside of the building for washing the car.

There should be provision for daylight to enter at each end, whether doors are fitted at both ends or not. The doors should have top panels of glass, supplementing a window at each side where light is not cut off by adjacent buildings or a fence. A roof light is another desirable feature, though with a brick building the space under the roof may serve as a loft for storing household and garage requisites required only at certain times of the year.

Water should be laid on if the car is to be washed at home, while an electric light installation is obviously desirable. There should be at least two hanging lights, but not at the centre, for central lights cast a shadow when the car is in place or when anyone is working at the bench. If only one hanging light is fitted it should be over the bonnet of the car. The best arrangement is two wall lights, one at each side and one hanging light over the bonnet. A plug for an inspection

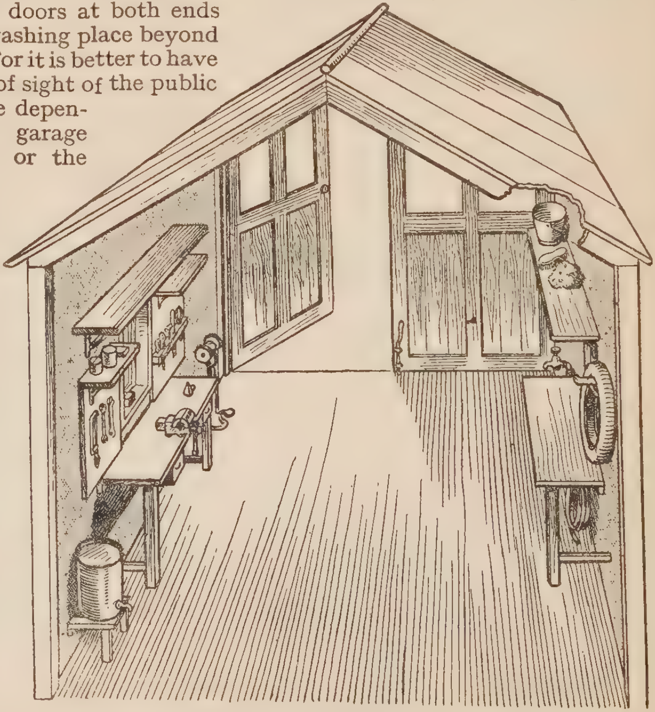


Fig. 184.—A well-planned garage.

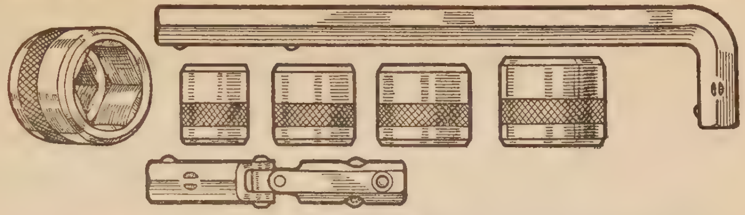


Fig. 185.—Set of useful Box Spanners with Hexagonal Tommy Bar and Universal Jointed Link for use in awkward positions.

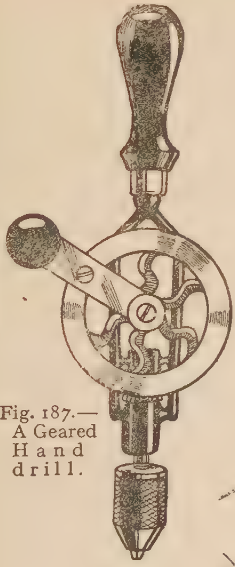


Fig. 187.—A Geared Hand drill.

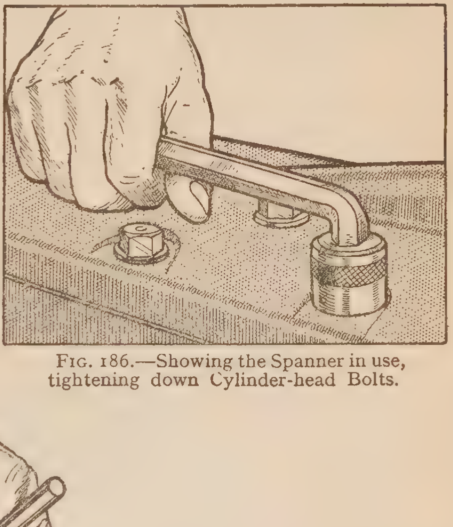


Fig. 186.—Showing the Spanner in use, tightening down Cylinder-head Bolts.

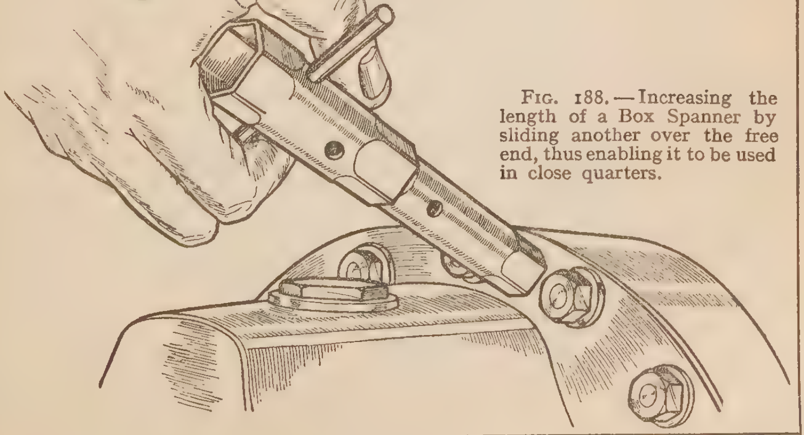
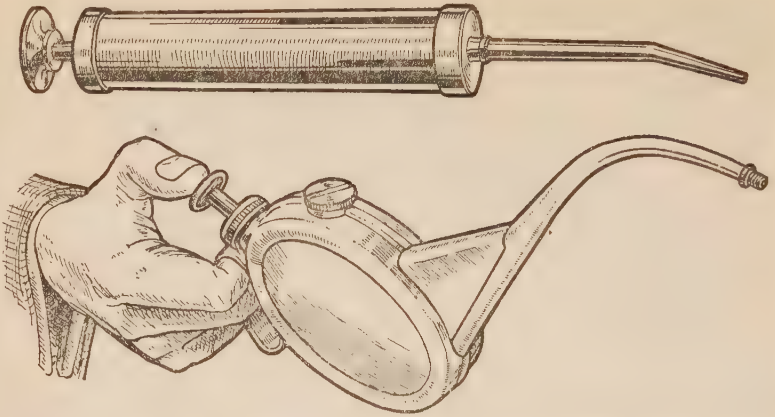


Fig. 188.—Increasing the length of a Box Spanner by sliding another over the free end, thus enabling it to be used in close quarters.



FIGS. 189 and 190.—A Petrol or Oil Syringe is a useful accessory which can be put to many uses in the garage or repair shop.

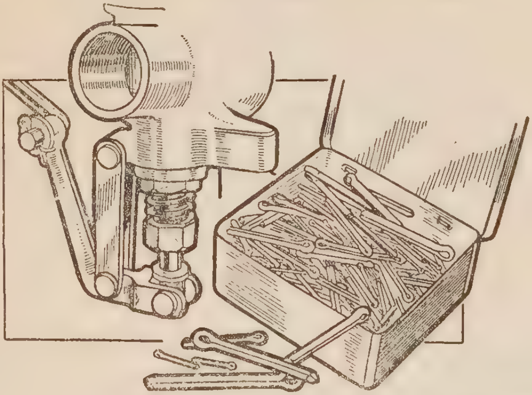


FIG. 191.—The motorists' Tool Kit should include a box of assorted Split Pins. How a Split Pin may be used for securing the control rod of a carburettor is also shown.

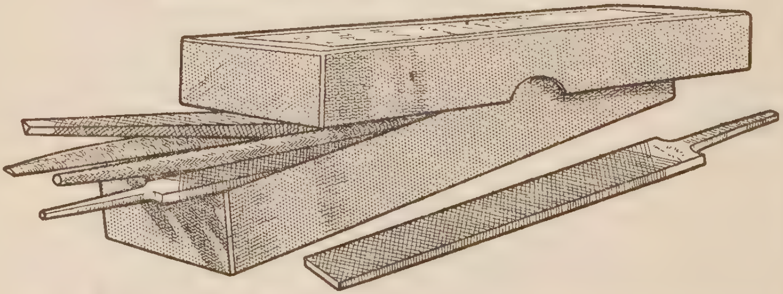


FIG. 192.—Handy box of Assorted Files of particular use to the practical motorist.

lamp with a flex long enough to allow the lamp to be taken around to any part of the car should always be included in the lighting equipment.

Optional Tool Equipments.—As regards tools, there will be the set belonging to the car, but as a rule these will be of rather poor quality and a poor assortment. Some owners rarely attempt to make use of the car tools, except the special ones made for certain parts of the individual car, such as the valve spring lifter or compressor and spanner for adjusting valve clearances. The wheel-brace is another exception, but the jack is not; the latter is not used in the garage but is kept on the car, stowed away for use on the road, a quick-acting jack being retained for garage use alone.

Assuming that the owner-driver has no tools except those provided with the car and that the latter are to be reserved for use away from the garage, the following to form the garage equipment are advised, the two lists indicating the measure of the owner-driver's ability and inclinations in regard to car upkeep:

Tool list A. For Adjustments, Valve Grinding, Decarbonising and Simple Repairs and Replacements.

4 in. parallel jaw vice; 2 in. hand vice; 1¼ lb. ball pane hammer; ¾ lb. cross pane hammer; 3 screwdrivers, 2 in., 6 in. and 10 in.; 10 in. gas pliers; 8 in. flat nose cutting pliers; 7 in. cutting nippers; 5 in. snipe nose pliers.

6 in. "King Dick" or Lucas "Girder" wrench; 12 in. Billings wrench; set of double-ended spanners, ¼ to ¾ in.; set of box spanners, ¼ to ¾ in.; box spanner for sparking plugs.

Assortment of files and handles (including 8 in. ½ round second cut; 10 in. flat, bastard; 6 in, flat, fine, safe-edge; 8 in. square, second cut; 6 in. rat-tail; 10 in. round, second cut). Hacksaw frame (8 in, or 9 in.) and half-dozen blades, fine and coarse; 6 in. pin punch; ½ in. cold chisel.

Oil squirt; petrol syringe; pocket flash lamp; roll of insulating tape; 2 rolls of copper wire, thin and thick.

Garage jack (*e.g.* Millennium "Express"); foot-pump; valve spring lifter; roll of hose for washing, pail, 2 sponges and leather. Roll of mutton-cloth for cleaning. Wooden stand, 12 in. high for 5-gallon oil drum.

Tools and Equipment.—List B.—Additional to A, for the owner-driver amateur-mechanic.

6 in. screw-cutting treadle lathe, with or without milling attachment; treadle tool grinder; set of lathe tools for steel and wood; 12 in. double-gear hand drill; breast drill for drills up to ½ in.; set of twist drills, 1/16 to ½ in. (in 1/32 up to ¼ in. and 1/16 from ¼ to ½ in.); 6 in. centre punch; inside and outside callipers; one-foot steel rule; pair of spring dividers. Pair of 10 in. tinman's snips; 1 lb. copper hammer; copper vice clamps; soldering iron; ½ pint blow-lamp; 7 lb. sledge hammer or small anvil.

The amateur mechanic among owner-drivers will doubtless find himself, from time to time, in want of tools beyond those specified (such as bearing scrapers), but personal experience and the extent of the individual's capabilities and intentions must decide which of these items of a still more elaborate equipment are justified. (See also *Spanners.*)

GAS.—Matter in its most easily compressible state. It may be regarded as the vapour of a low boiling-point liquid.

See *Vapour.*

GAS-FILLED.—Name given to electric bulbs which, after having been exhausted of air as completely as possible, have had introduced into them certain inert gases, such as argon, nitrogen, helium, etc., under varying pressures. They develop a brilliant light. Gas-filled bulbs are much used for car headlights.

GASKET.—A washer of packing material such as asbestos, thin rubber, oiled fabric, etc., which is placed between two metal faces in order to produce a gas-tight joint. Such packings between metal faces and flanges are termed " gasket-joints."

GASSING.—An electrical term referring to the liberation of oxygen and hydrogen in an accumulator cell which takes place during the end stages of its charging.

The effect is sometimes seen in car accumulators which tend to become over-charged. " Gassing " often causes the level of the electrolyte in the accumulator to fall below its normal level. This should be made up for by the addition of pure water.

GATE.—A slotted quadrant of hard metal which provides a means for the gear lever to be secured in various convenient positions.

GATE CHANGE.—Term referring to the method of changing gears, the gear lever being moved into various positions in the gate.

GAUGE. — An instrument for measuring the quantity and/or the pressure of a gas, liquid or solid in a system. A petrol gauge fitted to the tank indicates the *amount* of petrol present; an air-pressure gauge attached to the tyre valve measures the pressure of the air within the inner tube.

The term gauge is also used to refer to a standard of measurement.

GAUZE STRAINER.—Name usually given to a small cylinder or disc of fine gauze which is fitted to the carburettor fuel-supply pipe just before its point of entry to the float chamber of the carburettor. Its purpose is to prevent any particles of foreign matter from securing admission to the carburettor mechanism.

Similar straining and filtering devices are usually fitted to the oil and fuel supply systems of engines.

GEARBOX.—A train of pinion wheels suitably arranged in a metal casing the function of which is to allow various combinations of the wheels to be engaged, thereby enabling engine power to be transmitted from the crankshaft to the road-wheels in varying ratios.

The metal casing or box in which the gear trains are enclosed.

Overhauling.—There really is very little the amateur can do in this way of repairing a gearbox. Replacement of the worn or broken parts is the quickest and cheapest way. But gearboxes are notoriously trouble-free, and provided they are kept filled to the correct level with oil, they outlast the car. Trouble usually gives evidence of itself; a groaning sound indicates a bent shaft, a harsh sound a defective ball-race, and worn dogs by a tendency for the gear lever to jump back into neutral.

It sometimes happens that the selector-rod breaks adrift from the gear lever, in which case the gears cannot be engaged. Removal of the top of the gearbox will usually reveal the trouble—quite a simple one to rectify. Before examining the gearbox drain it and flush out with paraffin; this will make inspection easier.

GEAR CHANGING EXPLAINED.—It is impossible for anyone to become proficient at changing gear by reading a book, but the process of learning to perform the necessary operations is considerably simplified if the relevant principles are understood. Whether changing up or down, one must consider the question of the ratio between the number of revolutions per minute of the engine crankshaft and the corresponding revolutions of the rear wheels. If, for example, the gear ratios of the car were 20, 15, 10 and 5 to 1 respectively in the four forward gears the crankshaft would have to revolve 20, 15, 10 and 5 times as quickly as the rear wheels when the first, second, third and top gears were engaged.

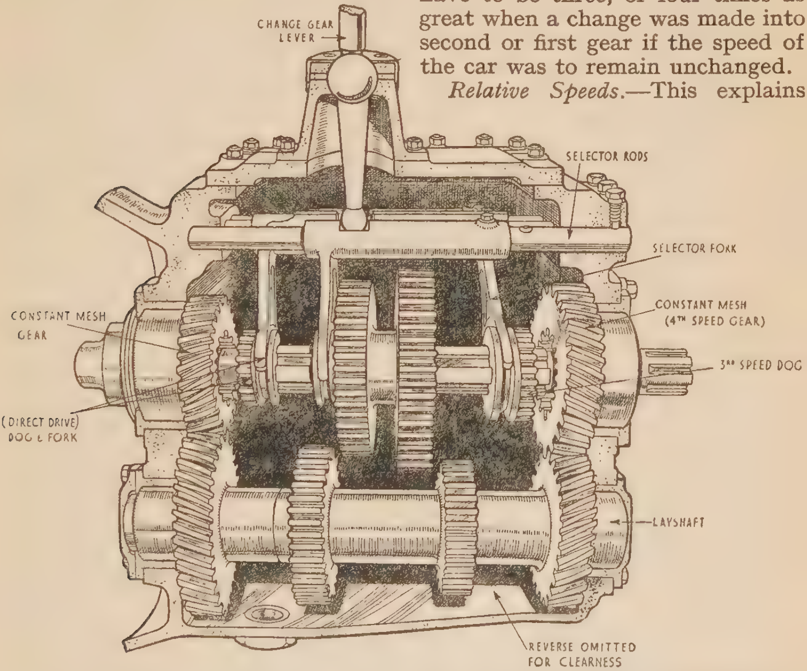

CHANGE GEAR LEVER
SELECTOR RODS
SELECTOR FORK
CONSTANT MESH (4TH SPEED GEAR)
3RD SPEED DOG
CONSTANT MESH GEAR
(DIRECT DRIVE) DOG & FORK
LAYSHAFT
REVERSE OMITTED FOR CLEARNESS

FIG. 193.—Internal view of a modern gearbox, which shows what happens when the gear-lever is moved into its various positions.

Stated differently, the number of revolutions per minute of the engine, for any given road speed, would have to be twice as high when third gear was engaged as when the car was driven in top. In the same way, the engine revolutions would have to be three, or four times as great when a change was made into second or first gear if the speed of the car was to remain unchanged.

Relative Speeds.—This explains why the engine revolutions have to be increased, by depressing the accelerator, when changing down, and reduced, by releasing the pressure on the accelerator pedal, when changing up. The idea is that the road speed remains sensibly constant, and therefore the engine speed has to be varied in proportion to the gear ratio.

It will also be understood why, in the case of most cars, a pause has to be made in neutral whilst changing up ; the rotating member of the clutch has to have time to slow down to the speed of the propeller shaft, which corresponds with the speed of rotation of the driving wheels.

Different drivers adopt slightly different methods of changing gear, but the following methods are generally considered to be as good as any. When changing up the clutch pedal should first be depressed, the gear-lever taken out of the notch representing the lower gear and the clutch again let in at almost the same time. Immediately after the clutch has first been depressed the accelerator pedal should be released to allow the engine speed to drop. After the car has run for a second or so (the actual time depends entirely upon the car) the clutch should again be put out and the gear-lever moved into the new position.

When changing down the procedure is practically the same, except that, instead of removing all pressure from the accelerator, the pedal is given a sharp jab to increase the speed of the engine. The degree to which the engine must be speeded up can only be judged by experience unless a revolution counter is fitted, but after very little practice the driver will find it quite easy to estimate the engine speed by ear.

The methods just described are those which are most suitable for the average driver when handling a standard car, but they have to be modified in special cases, such as when driving a racing machine in which the clutch plate has been specially lightened to enable rapid changes to be made. Then again, there are special methods involving a certain slipping of the clutch, and these are used in racing practice although they should not be tried by the average driver, for they will probably lead to damage.

Confidence.—As with all other operations which demand the use of skill and experience, it is essential that gear-changing should be undertaken in a determined manner. In other words, once it has been decided that a change into another gear is desirable the change should immediately be put into effect, moving the gear lever firmly but carefully. It is no use being somewhat afraid of making a bad or noisy change when first learning to drive, for complete confidence must be gained as quickly as possible. At the same time, there should be no attempt on the part of the driver to force the gear-lever into its new position ; if it does not slide in easily and without the exertion of appreciable pressure it is far better to free the clutch, rev. up the engine or allow it to slow down (according to whether the change is being made down or up) and then to try again. Provided that the road is clear, the process should, if necessary, be repeated constantly until a really quiet change is effected.

The gear-lever should never be *gripped*, but should be held comparatively loosely between the thumb and the first two fingers ; it will then be almost impossible to do any serious damage by forcing the gears into mesh whilst they are revolving at the incorrect relative speeds. This should be any easy matter, after a little intelligent practice, with any car which is in good condition and whose clutch " frees " properly. The fact that the clutch does function correctly can be checked by engaging the first gear whilst the car is at a standstill. If there is a "grating" or "rattling" sound when this is done the clutch is probably in need of attention.

When the Engine is Cold.—Another point which should be borne in mind in connection with gear-changing is that conditions are considerably different when the car is first started (especially in cold weather) than after the oil in the gearbox and back axle have become quite fluid. Thus, when changing up before the oil has become slightly warm a much shorter wait in neutral is required before engaging the higher ratio. In fact, it is often better not to double de-clutch under such circumstances, but to depress the clutch pedal, close the throttle and move the gear-lever into its new position almost as a combined action. Conversely, when changing down while the gearbox oil is cold, a longer pause must be made in neutral and the accelerator must be depressed for a rather longer period.

One more point which is worthy of mention—although it will soon be noticed by the driver—is that (assuming the car to be warmed up) the pause in neutral when changing up, and the degree of acceleration when changing down, should roughly be proportional to the road speed at the time.

When to Change.—It only remains to consider the most appropriate time for changing gear, as this is just as important as the methods employed. Normally one should change to a lower gear on hills immediately the car speed falls to about half the comfortable cruising speed. When an extremely steep or difficult hill (for instance, one which has a number of sharp twists, or which has a poor surface) is encountered, any except the most expert driver can be well advised to change "down" long before the speed has had a chance to drop off. By this means the engine revolutions can be kept high and there will be no danger of the car "stalling" before the summit of the hill is reached.

Although many drivers omit to do it, a change to a lower gear should for preference be made, even on a level road, whenever the speed falls off to such an extent that the motion is at all jerky, or when the car fails to accelerate smoothly as soon as the throttle is opened slightly. In any case it always pays to "drop down" when a quick get-away is desired after the car has been slowed down in traffic, or after rounding a fairly sharp bend. By doing so the engine is not stressed so heavily and time as well as wear is saved.

Practice Makes Perfect.—It is most desirable that every new driver should thoroughly master the art of gear-changing, and in this respect there is no doubt whatever that "experience is the best tutor." First take the car on to a straight and level road; change from one gear to the other until top is reached, and then allow the car to slow down to about 20 miles an hour and try to change into the next lower gear without making any sound. Changing up silently will in nearly every case prove to be a very simple matter, but the downward change will be far more difficult. After a little experience has been gained in this way, take the car on to a slight up-grade and repeat the process. It will now be found that the change down has to be made more quickly or else speed will be lost and the car will probably fail to "pick-up" after the lower gear has been engaged.

Driving a Pre-Selector Gear Car.—Cars fitted with pre-selector gears can be divided into two classes—those with and those without a fluid flywheel. Those without the fluid flywheel are fitted with a normal clutch action; that is to say the clutch has to be "let in" in the same way as with a manual gearbox.

Taking the fluid flywheel car first, it should be remembered that it is impossible to stall the engine, and that the amount of "slip" between the engine and the gearbox is governed entirely by the engine speed. The "slip" on a car with the usual lay-out is controlled by the action of the foot on the clutch.

Starting Away.—When starting the engine, the gear-selector lever should be in neutral and the "clutch" pedal given a jab to put the gearbox in the free position. With the fluid flywheel, the car can be moved off without damage in any desired gear. Thus if top is pre-selected and the pedal jabbed, this gear will be engaged. If the engine is idling and the hand brake applied, nothing will happen until the hand brake is released. Then the car will creep forward slowly. On the accelerator being depressed, the car will gradually pick up. If we start off in top in this manner the "get-away" will be slow, but no stress or strain will be put on any part. To make the normal start, first gear is pre-selected, the pedal is jabbed and, when the hand brake is released, the car will move off. Depression of the accelerator will speed matters up. As soon as the car moves, second gear should be pre-selected and when the necessary speed has been reached, a jab on the pedal will put the car in second. Though it is absolutely impossible to make any noise with the gears, they will take up a little more sweetly if the accelerator pedal is released momentarily when the gear is being engaged. For particularly snappy acceleration some drivers keep the accelerator hard down all the time. Having engaged second, third and top are engaged in the same way, without any fuss or noise. Should it be desired to change down it is only necessary to engage the necessary gear by a jab on the pedal after pre-selecting it on the steering column. In this case the accelerator is kept depressed.

Stopping.—No normal clutch being provided it is not necessary to touch the pedal when stopping the car, though after driving a car with an orthodox gearbox, one tends to "go through the motions" by force of habit. The car is brought to a standstill by simply releasing the accelerator and applying the brake. If a long stop is being made, neutral should be engaged; but in traffic, first gear should be selected, and it will only be necessary to release the brake and accelerate when it is required to move off.

The hand brake should always be "on" when the car is stopped with the engine running, or it will creep forward slowly if in gear. It should be noted that the "clutch" pedal does not come fully back when the gear is in neutral though it does so when the other gears are engaged. With the fluid flywheel it is most important that the engine idles properly. When the car is in gear and the hand brake applied, there is a certain amount of resistance to the engine. This slows down the idling rate very considerably and, if the rate has been set very low with the engine free, it may stall. Dead slow idling is neither desirable nor economical, and can be the source of a considerable amount of annoyance if the engine constantly stalls.

Pre-selection.—When the car has no fluid flywheel, the normal clutch action has to be gone through. When starting off, the clutch is engaged gently and when changing up or down it is let in with the normal movements. A little skill is required in manipulating the pedal so as to get a really smooth take-up, but this is acquired in a few miles. The actual gear change is the same as with the fluid flywheel car. First the gear is preselected and when the clutch is depressed it is engaged. When starting off from the stand-still, first gear is pre-selected and the depression of the clutch engages it. The clutch must then be let in gradually so as to make a smooth get-away. When changing up to second, the gear is pre-selected and the clutch depressed and let in again and so on. In this case the car will not idle with the gear engaged unless the clutch pedal is depressed and in this respect the normal practice is not changed.

Many motorists refrain from buying a pre-selector car because they think either that driving it is too complicated or that it is too easy and takes away the "joy" of a really successful gear change. In actual practice the car can be driven away by any normal driver after a very short perusal of the instruction book. An expert can make his gear changes so well, that the other occupants of the car do not know that he has changed at all. That is where the skill comes in. It should not be imagined that there is anything very complicated about preselection. Similar methods were used in tanks during the war with success and, though it has taken all these years to develop a suitable gearbox for a private car, most of the delay has been unconnected with mechanical difficulties.

GEAR RATIO.—The ratio between the input and the output speeds of a train of gear wheels.

Applied to car practice, the term denotes the ratio between the number of engine revolutions and the number of road-wheel revolutions, this difference being due to the interposition of the gearbox.

The majority of cars have a top gear ratio of approximately 4½ : 1. This means that the engine crankshaft revolves 4½ times for every revolution of the rear road-wheels.

GEAR SLEEVE.—An assembly of gear wheels mounted in such a manner that they can be moved along a shaft.

GERMAN SILVER.—See *Nickel Silver.*

GILLED-TUBE RADIATOR.—A type of car radiator comprising a number of vertical tubes each carrying a number of metal fins or "gills" from which the water heat is radiated.

GLAND.—A fitting for providing a gas or liquid-tight joint around a revolving rod, shaft or other moving part. It usually comprises a screw-cap arrangement or some other packing device which is fitted at the end of the revolving shaft in order to prevent oil leakage through the bearing.

GLASSPAPER.—Paper to which finely powdered glass is attached. Used for smoothing the surface of various materials. The popular term "Sandpaper" is synonymous with it.

GLASS WOOL.—A fibrous material composed of finely spun thread of glass. It has been used in car batteries as an anti-splash material but has not proved very satisfactory for that purpose owing to its tendency to interfere with the reactions taking place within the cell.

GLOBE JOINT.—A joint giving free movement between two rods or shafts. Similar in principle and construction to a ball and socket joint.

GLYCERINE. — Chemical formula: $CH_2OH \cdot CH(OH) \cdot CH_2OH$. Trihydroxypropane. A colourless, sweet-tasting syrup of specific gravity about 1·26, obtained as a by-product in the manufacture of soap from fats.

On account of its property of depressing the freezing point of water, it is used by motorists as an "anti-freeze" for the radiator water in cold weather, being added to it in the proportion of about 1 part of glycerine to 5 or 6 parts of water.

Synonym: *Glycerol.*

From the Greek, *Glykys*, sweet.

GOLD SIZE.—Name given to a thick brown liquid of varying composition. It is used for making cylinder joints, etc., and generally comprises a solution of resin in oil, the solution being heated and treated with litharge.

GRADIENT. — The extent to which the contour or slope of a road departs from the horizontal. It is measured by the ratio between the distance travelled and the vertical height of the slope. Thus a gradient of 1 in 4 means that for every 4 feet of road there is a rise (or fall) of 1 foot.

The practice on the Continent and in America is more usually to express gradients in percentages. A 1-in-10 gradient is called a 10 per cent gradient; a 1-in-5 a 20 per cent gradient.

GRADIENT METER.—A device which indicates the steepness of the gradient up or down which the car is travelling.

Gradient meters often consist of a spirit-level instrument, which, to be accurate, must be perfectly adjusted and read only when the weight is equally distributed over the car.

GRADOMETER. — A gradient meter.

GRAPHITE. — A naturally occurring form of the element, carbon. It forms the basis of most dry lubricants. It possesses a metallic lustre and a greasy touch. In fine powder form and in admixture with a little grease to act as a binding substance it forms a good lubricant for surfaces which are exposed to dust, for, being dry, the dust particles do not tend to stick to it.

A more refined use for high-grade graphite consists in its admixture with oil and its employment in this state as a gearbox lubricant.

GRAPHITED OILS.—Oils of high viscosity with which is incorporated graphite in an extremely fine powder. They are used for lubricating gearboxes, heavy bearings, etc.

GRASSHOPPER SPRINGS. — Name used to denote certain types of semi-elliptical springs used on some cars to absorb road vibration.

GRAVITY.—The force of attraction between bodies, notably between the earth and a body on its surface. The influence of gravity is made use of in many ways in car technics, as, for example, when a car makes use of the engine-braking effect when going downhill.

GRAVITY-FEED LUBRICATION.—An old system of lubrication in which the oil was contained in a tank or other vessel secured to the car dashboard or elsewhere and was delivered through pipes to the engine bearings under the force of gravity.

GRAVITY SUPPLY.—Term usually denoting the method of supplying fuel to the carburettor of an engine directly from a tank set in a higher position, the flow of the fuel thus being directed by gravity.

For many reasons this method of fuel supply is becoming obsolete on cars, although it is invariably employed for motor-cycles.

GREASE.—Thick and semi-solid oil used for lubricating heavy bearings. Pure motor grease should be of a yellow colour with a greenish tint.

GREASE CUPS.—Metal cups provided with screw-caps which are fitted above various bearing surfaces of the car. They are filled with grease and by the periodical screwing down of their caps grease is forced between the bearing surfaces.

GREASE GUN.—A force pump or injector for forcing grease into a conduit or a bearing.

GREASERS.—A name given to grease-cups of more or less specialised pattern.

GROUND-CLEARANCE. — Applied to cars, this term denotes the distance between the ground and the lowest projecting point beneath the vehicle.

GUDGEON PIN.—A steel rod which passes horizontally through the piston on its underside and which serves to connect the little end of the connecting rod to the piston, thus enabling power to be transmitted to the crankshaft.

GUN METAL.—A fairly hard and extremely tough alloy composed, generally, of 90 per cent of copper and 10 per cent of tin. Gun metal has been used in the past for the construction of crankshaft and other motor bearings.

Gun metal of a harder quality but more brittle may be made by increasing the percentage of tin in the alloy.

GUTTA PERCHA.—A natural product similar in chemical composition to rubber, but tougher and hornier.

It is used to a great extent in the unvulcanised condition as an insulating material for electric wires, cables and instruments of all descriptions.

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HALF-ELLIPTIC SPRINGS. — Name given to leaf springs which by their mode of attachment to the frame of the car form a semi-ellipse.

HALF-FLOATING AXLE. — See *Semi-floating Axle.*

HEADER.—The top removable portion of the cooling system of a car which conveys the water to the radiator.

HEADLIGHTS.—Name given to the two powerful lamps set in front of the car which project strong beams of light on to the road in front.

HEAT.—A manifestation of energy due to the rapid motions of the constituent particles of a substance. The higher the velocity of its constituent particles, the higher the temperature of a body. Thus temperature is really a measure of the average velocity of the constituent particles of a substance.

The effective utilisation of heat energy is the fundamental principle upon which all combustion engines depend.

HEAT EFFICIENCY.—See *Thermal Efficiency.*

HELICAL GEAR.—Wheels, the teeth of which have a curved formation to give smoother running than wheels having straight-cut teeth.

HEPTANE.—Chemical formula: C_7H_{16}. A colourless hydrocarbon liquid. Boiling point 98°C. Specific gravity 0·683. A constituent of petrol fuels.

HERRING-BONE BEVEL WHEEL.—See *Chevron Bevel Wheel.*

HEXHANE.—Chemical formula : C_7H_{14}. A colourless hydrocarbon liquid. Boiling point 69°C. Specific gravity 0·658. It is a constituent of petrol.

HIGH-TENSION CIRCUIT.—Literally, a circuit which carries electricity at high tension or pressure. The circuit which carries to the plugs the high-tension current from the magneto or secondary winding of the coil.

HIGH-TENSION WIRE.—Specially insulated wire made for the purpose of carrying current at high pressures. The term is usually applied to the wire which runs from the magneto or coil to the plug terminals. It consists of a number of stranded wires which are heavily insulated. Abbreviation : *H.T. Wire.*

HIRE PURCHASE.—There are three ways of purchasing a car : For cash, by deferred payments and on the hire-purchase system.

Purchase by cash requires no explanation, but things are not so simple if either of the other two methods are employed. The system of deferred payments is not much used now. By this method the purchaser actually buys the car when the agreement is signed. He becomes the sole possessor of it the moment his first payment is handed over. The balance of the purchase money is debited to the purchaser who signs an agreement, undertaking to pay so much per month, plus interest, until the amount is cleared.

Should the seller of the car fail to collect his instalments for any reason, his only redress is in the Courts. In some cases the agreement stipulates that the car can be seized by the seller if the payments are not kept up, but this clause has been found rather difficult to enforce in law.

With a hire purchase agreement the system is different, and gives more protection to the unfortunate seller who fails to collect his money. In this case the buyer makes a first payment, which is in consideration of the option to purchase the car. This sum is credited to the buyer if he does actually complete the purchase, but should he fail to do so, he must lose his money.

The seller then agrees to hire the car to the buyer for so many months at the sum of so many pounds and so many shillings per month. At the completion of the hire the hirer then has the option to purchase the car for a nominal sum. This is usually five shillings. All this means that the total amount of the hire, plus the first payment, equals the price of the car with the interest for the financial accommodation added.

In order that the seller may collect his property without interference from the hirer, a clause in the agreement allows him to enter premises and break open gates and doors to recover the car. A car obtained on the hire purchase system cannot be seized under a court order nor must it be sold by the hirer. The hirer must keep it fully insured under a full comprehensive policy, taken out with a company approved by the seller. He must not ship it abroad without the express permission of the seller and he agrees to keep the vehicle in good repair at all times.

Actually a hire purchase agreement has no pitfalls for the honest buyer, who has the means to pay his instalments without difficulty.

Only the largest car dealers finance their own hire-purchase. The majority arrange the hire through one of the large financial concerns, which have been specially created for the purpose. These companies have nothing to do with the car itself and should it develop every kind of fault, the hire must still be paid.

A householder is not asked to provide a guarantor for the hire as was once the case. In fact, with anyone who can satisfy the seller that he is a good citizen, this formality is not insisted on. The interest charged on the hire is usually from 5 to 10 per cent per annum.

A large number of motorists pay their first instalment on a new or used car by trading in the vehicle they already own. Then they have only to pay the balance in hire to complete the purchase. This is often the best method of disposing of an old car, which has little market value, as most dealers will make an offer for it if there is a chance of selling a better car into the bargain.

Hire purchase enables a motorist with a steady income but no capital to purchase a car and " Pay as he rides." The system is so common now that the majority of cars are probably sold by this method.

HODOMETER.—An instrument for registering the revolutions of a road wheel and recording them in terms of mileage travelled.

See *Odometer*.

HOLDING-DOWN BOLTS. — A term sometimes given to bolts which secure together one part resting upon another. The engine, gearbox, etc., when they rest on the upper side of the frame are secured by holding-down bolts.

HOLDING-UP BOLTS.—A term which describes bolts which secure or hold-up one member to another. Holding-up bolts have always to carry the weight of the lower fitting or member. Hence, compared with holding-down bolts, they are usually made stronger.

See *Holding-down Bolts*.

HONEYCOMB RADIATOR. — A type of car radiator, so named from its appearance and also known as a " cellular " radiator.

It consists of a large number of narrow tubes placed horizontally. Air passes through these tubes. The radiator water passes through spaces between the tubes, thus being exposed to a large cooling surface.

HOOD.—The folding roof and sides of the bodywork of a car.

HOOKE'S JOINT.—A type of universal joint, so-called after its inventor, Dr. Robert Hooke (1635-1702), a famous English philosopher and mechanician.

HORIZONTAL MOTOR. — An early motoring term applied to car engines the cylinders of which were placed in a horizontal position.

HORN.—Term used to denote the sound-producing instrument fitted to all cars for the purpose of giving " audible warning of approach."

See *Bulb Horn*, *Electric Horn*, etc.

HORSE-POWER.—The conventional unit of motive power. Technically speaking, one horse-power represents the power required to raise 33,000 lbs. 1 foot in 1 minute.

This standard is not an accurate one, for it has been shown that the power of an average horse, labouring at the rate of 8 hours per day, puts forth a maximum of 0·69 of the standard horse-power.

HOT-SPOT DEVICE.—An arrangement for heating up the mixture of fuel vapour and air before its entry into the cylinder. It is generally effected by making use of the engine heat or the heat of the escaping exhaust gases.

HYDRAULIC BRAKES.—The hydraulic brake uses a fluid as a means of transmitting the pressure from the driver's foot to the expanding shoes in the wheel drums.

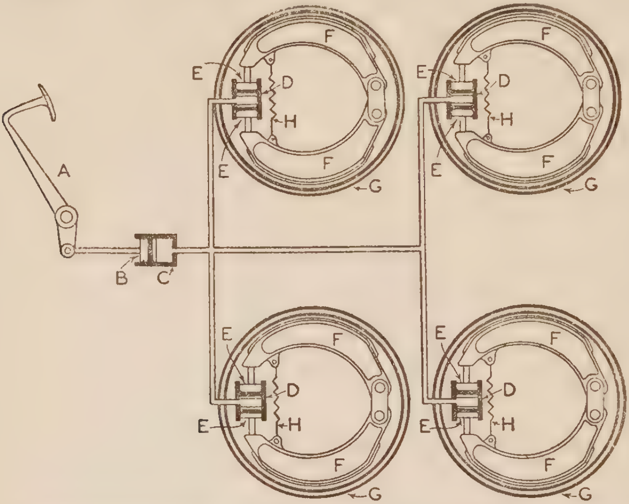


Fig. 194.—Seen diagrammatically, the simplicity of the hydraulic system at once becomes apparent.

This is shown diagrammatically in Fig. 194, where the pedal A, presses a piston B, in a master cylinder C, and forces the fluid (a special non-freezing liquid) through pipes to small cylinders D, situated in the wheel-drum back plates (fixed to the axle). Two opposed pistons E, E, in each of these cylinders, are pressed out by the pressure of the liquid and force the shoes F, F, apart and into contact with the inside surface of the drum G, thus applying the brakes. Since the liquid is incompressible, and since all the four brake cylinders are in pipe communication with the master cylinder C, it follows that foot pressure on the piston B will force the liquid, under identical pressure, into all the four-brake cylinders and produce an identical pressure on all the eight shoes of the four-wheel brakes. Fig. 195 shows the master cylinder as used on small cars. It is designed to maintain, automatically, a constant volume of the operating liquid in the system, when at rest, at a pressure of 8 lbs. per square inch. This pressure acts as a liquid expander to keep the rubber cups of the pistons (which prevent the escape of the liquid) pressed against the walls with sufficient pressure to keep the system effectively sealed.

Within the master cylinder is a piston A, having at its forward end a cupped washer B. This piston is normally held in the " off " position by a compression spring C, inside the cylinder. Immediately in front of the cupped washer B, when the piston is in the " off " position (as shown in the diagram) is a very small porthole D, which connects the cylinder with the hollow boss above it, this hollow chamber being in connection, by a pipe, with the fluid supply tank above. If a rise in temperature causes the fluid to expand a little it rises through this port and into the supply in the tank and its pipe. With a drop in temperature, which would contract the fluid, it returns to the master cylinder. So that a constant volume of fluid is automatically maintained in the system. The piston is pressed in, to apply the brake by the brake-pedal G, which presses the rod E, which is adjustable.

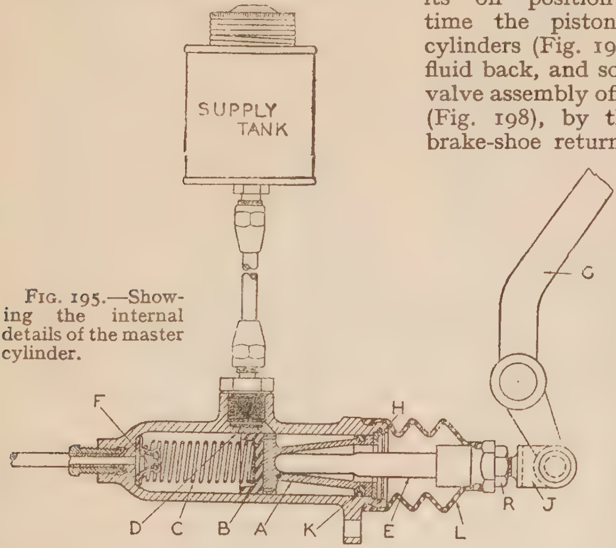


Fig. 195.—Showing the internal details of the master cylinder.

At the outlet end of the cylinder and held in place by the return spring C, is a combination inlet and outlet check-valve F. This is shown larger in Figs. 197 and 198, where it shows this valve as a hollow, conical sheet metal pressing A, containing a rubber cup B, shaped to fit closely to the inside of A and the whole seating on a flat rubber washer C, in the extreme end of the cylinder. When the brakes are applied the piston of the master cylinder (Fig. 195) is pushed forward by the pedal and fluid is forced through holes in the metal valve body A (Figs. 197 and 198), deflecting the rubber cup inwards and allowing the fluid to flow through the holes, past the lips of the cup, and out to the pipe-lines to the brake-cylinders, as indicated by the arrows. When the driver releases the brake-pedal the return spring C (Fig. 195) forces the piston back to its "off" position and at the same time the pistons in the wheel cylinders (Fig. 194) are forcing the fluid back, and so lifting the whole valve assembly off its seat washer C (Fig. 198), by the action of the brake-shoe return springs H (Fig. 194), until the fluid pressure balances, with the effort of the master cylinder return spring—and the inlet valve closes.

Adjustment of the Brake Pedal.—The push-rod E, of the brake pedal (Fig. 195) should have a slight clearance (looseness), where it seats in the piston A, when in the "off" position. If it were adjusted tightly against the piston, the little oil porthole D would be covered by the lip of the washer B, thus preventing the compensating action, described, for varying temperatures. To make sure that the piston comes back far enough to uncover the port D, the brake pedal G is allowed a slight amount of free movement before the rod E begins to push the piston. The fork-end J, of the push-rod E, is screwed into the latter and locked by a lock-nut R. Slack back this nut and then turn the hexagon

THE LOCKHEED HYDRAULIC BRAKE SYSTEM

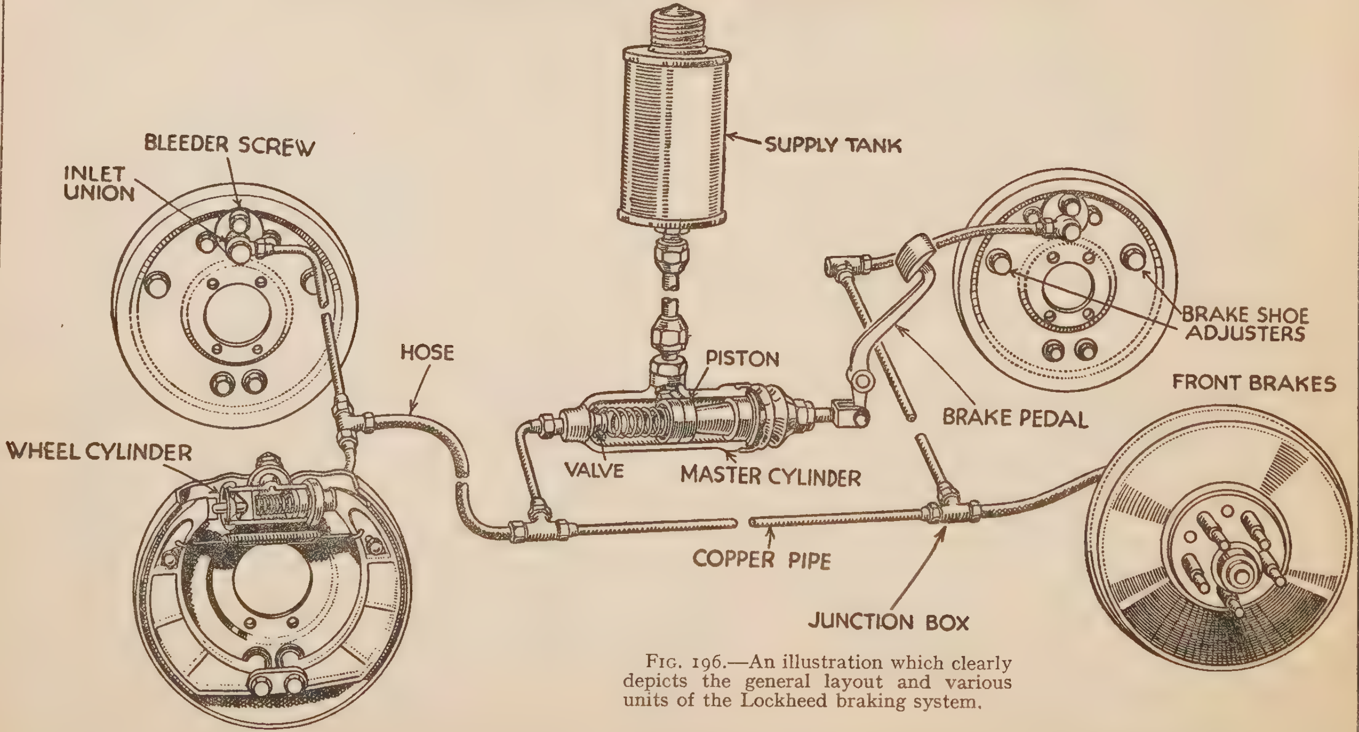

BLEEDER SCREW
INLET UNION
SUPPLY TANK
HOSE
PISTON
BRAKE SHOE ADJUSTERS
FRONT BRAKES
BRAKE PEDAL
WHEEL CYLINDER
VALVE
MASTER CYLINDER
COPPER PIPE
JUNCTION BOX

FIG. 196.—An illustration which clearly depicts the general layout and various units of the Lockheed braking system.

head S, of the push-rod E, towards the fork J, to let the piston back a little ; and turn it away from J to set the piston further forward. Then lock it with the lock-nut R.

The Wheel Cylinder.—In Fig. 199 is shown an internal (part sectional) view of the cylinder which expands the shoes. It is mounted rigidly to the brake-shoe back-plate, and the opposed pistons A and B act (through short push-rods H, H) on the ends of the brake-shoes, pushing them apart against the pull of the springs, which draw them away from the drum. The ends of the cylinders have rubber washers C and D to protect the cylinder from dust and dirt. The cylinder is shown diagrammatically, between the brake-shoe ends in Fig. 201. Between the two pistons (and shown in the transverse section of Fig. 200) is a bleeder screw E. When screwed back off its seat F, it allows air to escape through its hollow centre *via* the hole G in its side.

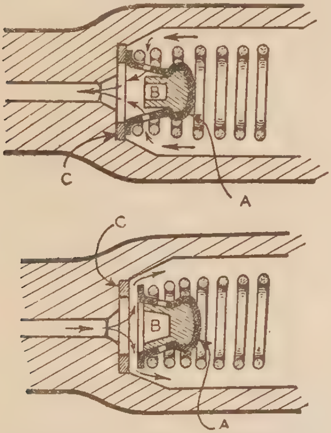


FIG. 197 and 198.—Showing flow of liquid past the valve when brake is applied and released.

When the brake linings are much worn the piston in the master cylinder (and the brake-pedal) will go to nearly the extent of their travel, and a point might be reached when the limit was attained, and the brakes would not go on strongly enough. Before this occurs, and when there is evidence of the brake-pedal going too far, the brake-shoes must be adjusted into closer relation to the drums. This adjustment is shown in Fig. 200.

Adjusting the Shoes.—The wheel having been jacked up the adjustment cam A (Fig. 201) is partially rotated against the stop-pin B, on the shoe. To do this rotate the hexagon-headed adjustment nut C, with a spanner until the brake-shoe comes into contact with the drum. Then back off the adjustment slightly till the wheel rotates just freely and without any perceptible drag. One turn of the adjustment nut is sufficient to take up all lining wear. In fact, it will be found that the adjusting nut C (which turns the cam) will require only a partial turn before the shoes are brought into contact with the drum. These adjustment nuts (one for each shoe) will be found at the back of the brake plate, behind the drum, and are shown at C, C, in Fig. 202.

Bleeding the System.—If any part of the fluid system has been disconnected it will be necessary to " bleed " the system to expel air. Any air will nullify the action of the fluid, as it is compressible, and the pressure in the master cylinder will not be communicated to the shoes.

To bleed the system, remove the set-screw at A (Fig. 202) from the end of the bleeder-screw, and screw in the bleeder-drain—which is a screwed brass nipple with a rubber tube—allowing the rubber tube to hang down into a clean glass, well below, as shown. Then unscrew the bleeder-screw E (seen in Fig. 200) one turn with the wrench B, which fits over the brass nipple, and depress the brake-pedal quickly allowing it to return fully and without assistance. This gives a pumping action (our master cylinder acting as a pump), and forces the fluid out at the wheel cylinder, carrying with it any air which may be present in the fluid, and which it is our object to eject. Ten strokes, at least, of the pedal will be necessary to bleed each wheel cylinder. Watch the flow of the fluid from the bleeder drain-tube, the end of which should be well below the surface of the fluid, and when all air bubbles cease to appear close the bleeder screw. This operation must be repeated on the cylinders of the other three road wheels and the supply tank (Fig. 195) replenished each time. If the supply tank should, by accident or inadvertence, be drained during the bleeding operation, air will be drawn into the system, and the whole operation will have to be repeated. Therefore keep it well supplied.

Some Concise Tips.—The following tips, in case of any slight trouble, will enable the cause of the trouble to be diagnosed, and will give the remedy.

Use only the genuine Lockheed brake fluid, which will not attack the rubber of the high-pressure connecting hose carrying the fluid under pressure when braking, nor will it freeze.

If the brake-pedal has excessive travel, adjust the shoes closer to the drum as described. If it is due to a leakage in the system, tighten the joints in the pipe-lines.

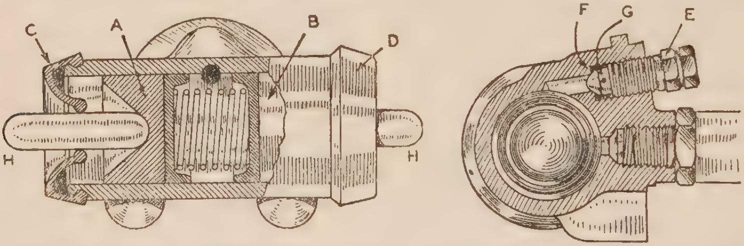
Keep the supply tank well supplied with fluid.

Keep grease off brake-linings, use all the same linings—" Ferodo " for surety. Knock down projecting lining rivets.

If brakes stay on when the brake-pedal is released, they may be too closely adjusted. They may be tight on their pivot pins—oil them. The brake-shoe pull-off springs may be loose or broken—replace them. There may be no initial clearance at the pedal. There should be half an inch of play at the back (off) position to allow the piston to pass the excess fluid port (as previously described).

Brake drag may be caused by too close adjustment of the shoes, or by worn wheel-bearings, or the use of spurious fluid in the system. The remedy is obvious.

If a flexible pipe-line gets damaged, or if the joints get loose and fluid is lost, the brake-pedal will have to be depressed a lot. If the leakage is serious the fluid will be all expelled and the brakes rendered inoperative. Tighten joints at once,



FIGS. 199 and 200.—Two sectional views of the ingenious cylinder and piston device which operates the brake shoes.

and bleed the system to expel air, and renew fluid, as already explained. Only the proper genuine Lockheed fluid can give satisfactory working and security against failure.

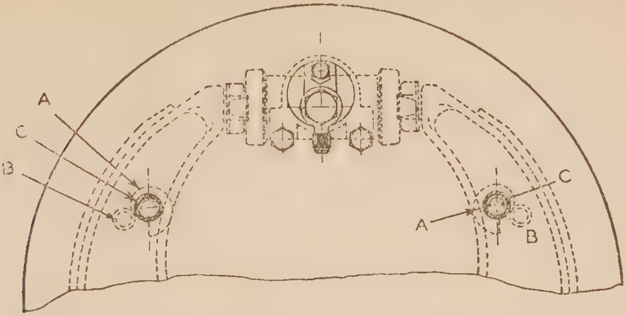


Fig. 201.—Ghost view from rear of back plate, showing cam adjustment for the brake shoes.

HYDROGENATION.—Name given to a commercial scientific process whereby motor lubricating oils of definite and constant properties are produced from inferior oils by mixing the latter with finely-divided nickel and by treating the mixture with hydrogen gas under considerable pressure. In this manner, hydrogen is chemically added to the thin oil, thereby converting it into an oil of greater viscosity.

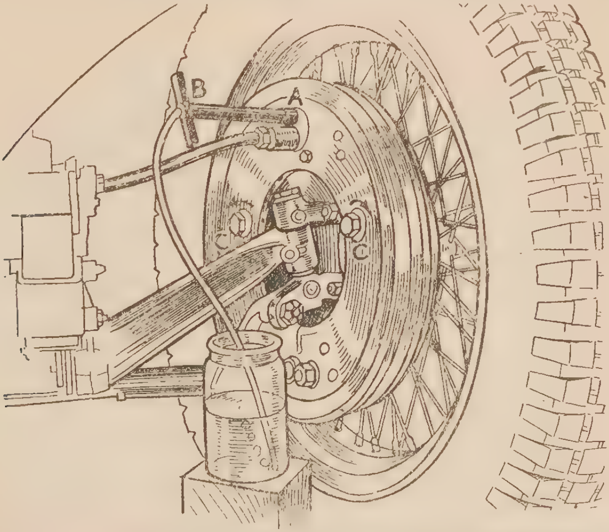


Fig. 202.—Known as "bleeding," the operation illustrated here and fully described in the text is one of the few adjustments which must be occasionally made to Lockheed brakes.

I

IGNITION.—The firing of the explosive mixture within the cylinder, usually by means of an electric spark passing at the plug terminals. The entire electrical system of the engine which permits of this operation.

IGNITION FAILURES.—Engine failure is 75 per cent due to ignition faults. Adequate care will easily reduce this figure to 10 per cent.

In dealing with ignition troubles it must be remembered that the wrong type of sparking-plug not only permits a very inefficient engine, but places a strain upon the ignition system as a whole. A plug cutting in and out will eventually destroy the coil entirely in a coil and battery system. Some engines are designed to run at much hotter working temperatures than others and, therefore, assuming twenty-six engines ranging from A to Z and fitted with plugs ranging from 1 to 26, it is obviously doubtful if " A " engine would run fitted with No. 26 plug, and *vice versa*. Clearly, then, the right plug must therefore always be used or many troubles will ensue.

The centre electrodes of plugs are subjected to very great electrical and mechanical strain in the modern high-speed, high-compression engine and therefore the replacement of plugs every 10,000 miles advised by manufacturers is a genuine necessity.

As soon as missing occurs the plugs should be removed and a " test " set fitted. A test set is not a collection of discarded and doubtful plugs, but comprises a number

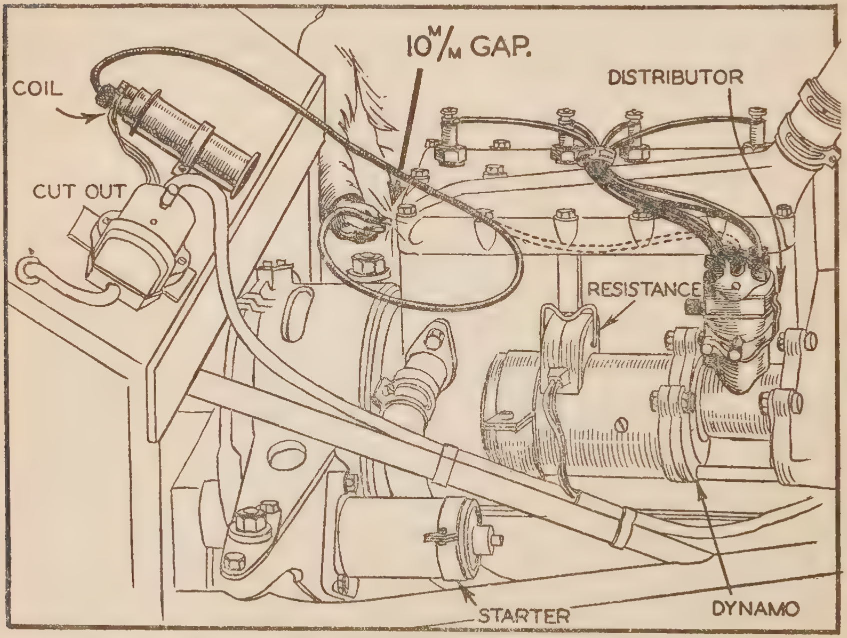


Fig. 203.—A test for spark and condenser trouble.

that have been thoroughly cleaned and tested under pressure at least half as high as the compression of the faulty engine. This procedure will settle the plug question and permit search in other directions with the assurance that it is *not* the plugs. Test by elimination in this way is the only check.

A quick test in locating an offending plug is to immediately feel the plugs with the fingers of the left hand after the engine has been running for some time. The cold plug will be the offender. (Left hand fingers are more sensitive than right, if the operator is right-handed.)

Coil Defects.—The coil itself is most difficult to deal with, but if the temperature rises above the normal it is a certainty that something is wrong inside. The breakdown may be through a fault that has been there from the beginning and which through continuous working at last comes to light, or it may be due to some outside influence.

A cause very seldom appreciated is the accumulation of metallic dust on the nose of the coil. Starting with unseen surface leakage the H.T. current eventually breaks down the Bakelite insulation and a direct spark jumps right through. Corrosion on the end of the H.T. lead is another source of failure, and once started, electrolytic action completes the trouble. It must be remembered that the engine fan draws much through the radiator besides air, therefore such deposits must be frequently removed. The coil must not be shielded from the cool draught of air or its temperature will rise and the internal insulation liquify. This insulation not only acts as a non-conductor but keeps the windings in place. If the interior gets into a plastic state, movement and breakdown will result. There is no test for coils, excepting on a proper test bench. Coils frequently have to be taken adrift to locate faults and because of this it is often cheaper to use a new one.

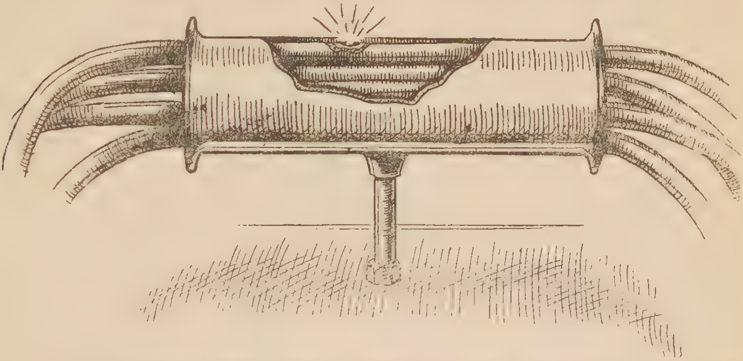


FIG. 204.—Perished wires in tube, sparking to earth instead of at plug points, especially if coil-to-distributor wire goes through same tube.

Timer Troubles.—Timers are fairly easy to check for faults, but they may set up some complex problems when once disturbed. It is advisable, in consequence to go to work very carefully, as the most innocent looking screw or wire may be the cause of accentuating the original fault.

Current always passes in one direction across the contact points, thus forming a crater on one point and a " pip " on the other. If the points are adjusted without cleaning there will be immediate ignition failure. Tungsten-iron, from which the points are made, whilst being a fair conductor when clean, is a very bad one when oxidised. As stated, this metal is only a fair conductor, and for this reason the points are made in ample proportion, and again it is a reason why tungsten cannot be substituted for platinium. If the points are adjusted without cleaning, the " pip " will perhaps be in contact with an oxidised face on the other point and great resistance will be offered to the flow of L.T. current. The points are only in contact for the fraction of a second, therefore the conductivity of the points must be right up to standard if an even firing is desired.

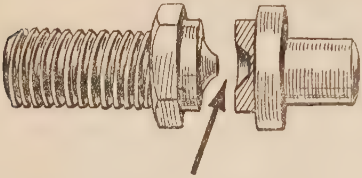


Fig. 205.—Timer points: one with pip and the other with crater.

Cleaning the Points.—This feature is also emphasised as the average owner adjusts everything he can see before taking stock of the actual situation. The points should be removed for cleaning; there is no other way, and they should be examined with a magnifying glass to assure that the surface of the point has been restored. Polish the points on a strip of fine emery, or carborundum cloth. A file is useless as the point is harder than the file. When replaced, the faces of the points should meet. If the screwed point is slightly rounded it will assure contact without much trouble. It is most difficult to get two flat surfaces to meet correctly, specially on a timer. It must be remembered that the tungsten is electrically welded on to the screwed point and there is often less material at the centre than the edges, therefore appearance does not always count. The correct gap is always stated in the makers' handbook. All screws should be tested for tightness, also examine all wires for frayed ends as they cause many

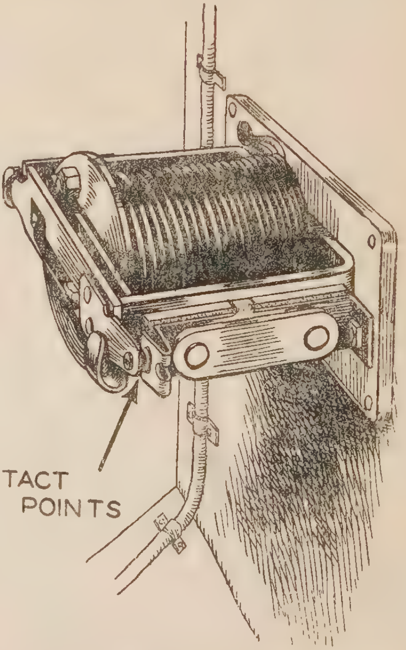


Fig. 206.—Showing the contact points on the cut-out.

mysterious short circuits. See that terminal ends, specially square ones, are in place as they are likely to push the insulating material from under them.

The Condenser.—To test the condenser without dismantling or the aid of special appliance, remove the distributor cover and rotor. Remove the distributor end of the H.T. wire running from the coil and hold it about 10 mm. from some bright spot on the engine. Having seen that the points on the timer are closed, snap them open several times with the finger. The value of the spark will invariably denote condenser condition. If it is " fat " it is good, if " thin " (wire-drawn), the insulation of the condenser has punctured and the capacity has been lost. The colour of the spark matters little as this mostly depends on the metal from which the spark jumps. If no sparks are present there is a disconnection in the circuit, although the ammeter should denote flow by the movement of the pointer. Ammeters, however, are at times very sluggish and not to be relied upon, also the ignition current does not always pass through the ammeter.

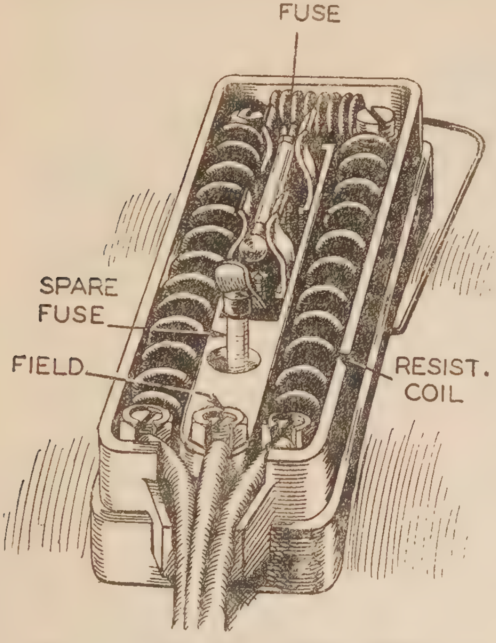


Fig. 207.—Inside of the fuse-box, showing the holder for the spare fuse and also the resistance coil for " half-charge."

The H.T. distributor cover is likely to have hidden faults caused through tracking of the H.T. current from one segment to another. Carefully remove and turn the cover up the other way so as not to disturb the dust inside. A rag, well damped with petrol, wiped around the interior will often wash the dust into the hidden crack. Replace the cover and start up the engine, when, if the cover is at fault, the misfiring will increase. Removal of the cover will show the actual line of tracking caused by the increased conductivity of the path due to the wet carbon being washed into it. A caution is that the cover must not be returned flooded in petrol, otherwise it will catch fire. If faulty, the cover will have to be discarded as it cannot be " faked " up. Like the coil, the cover should be cleaned regularly and so lower the chances of trouble.

Rotor Failures.—The rotor should be examined for similar cracks immediately under the tension spring. This is not a frequent trouble, but not being anticipated, is very misleading. The "wipe" will be seen to have been burned away, and, if too much, it should be renewed. The burning of the wipe is not the cause of trouble, although often thought to be so. Very often when renewed the trouble ceases, but only because the spark tension has been lowered and as soon as the wipe burns, the trouble returns; therefore do not be misled.

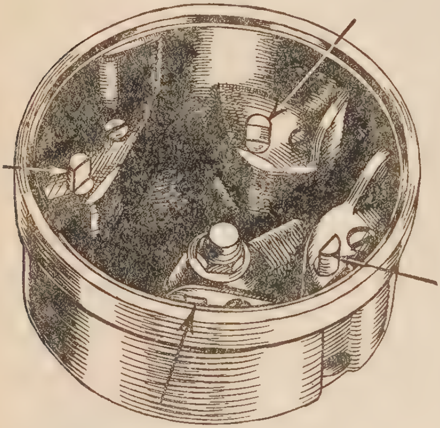


Fig. 208.—Inside of the distributor cover showing the track after being revealed with the aid of petrol.

The H.T. wires themselves should be separated and examined, also the engine performance should be observed during their movement. The hardened surface of the wires is a good starting point for leakage and the cause of much trouble.

Present practice is to loop the ignition and switchboard wire from some spot on the starter circuit, and so connections between these points should be examined, as also should the rear of switchboard terminus and connections. With the engine running, shake all wires about and observe the effect.

Should switchboard connections or controls be suspected, connect a wire direct on to the battery and hold it on to the correct L.T. terminal of the coil and observe the difference, if any. In investigating the numerous sources of ignition troubles already dealt with it should always be borne in mind that one of the main causes of failure is dirty terminals.

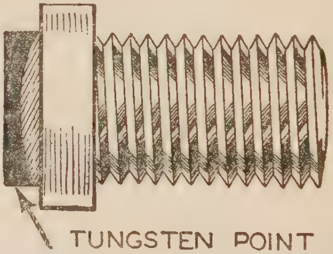


Fig. 209.—Tungsten point, showing that it is invariably thinner at the centre.

IGNITION LEVER.—Name given to a small lever which is sometimes placed on or near the steering-wheel of the car for the purpose of enabling the driver to control the spark-timing of the engine.

IGNITION-POINT.—The temperature at which a combustible liquid or an oil begins to give off a vapour which when a flame is brought into contact with it takes fire and burns continuously.

The ignition-point of a liquid fuel is, of course, a direct measure of its volatility or "lightness."

See *Flash-Point.*

IGNITION TIMING.—An expression referring to the mechanical timing of the ignition sparks of the engine so that they pass across the sparking-plug points in due and correct sequence.

THE IGNITION SYSTEM.—We now come to that part of the car's mechanism which is least understood—the ignition system. Sometimes this consists of a magneto, but nowadays the coil ignition system is mostly used. The chief advantage of this latter system is that the quality of the spark is entirely independent of engine speed, and therefore it makes starting even a cold engine comparatively easy. Another advantage is its low cost, and the tendency seems to be to revert to coil ignition. The magneto, however, will not be entirely superseded for many years to come. Its introduction solved the difficulty of the unreliability of the early cars, all of which were coil-ignited but the fact that coil ignition depends upon the battery has not militated against its popularity. The magneto, on the other hand is an entirely satisfactory and self-contained piece of apparatus. Seldom does it give trouble. As the coil is the simplest system, it will be dealt with first.

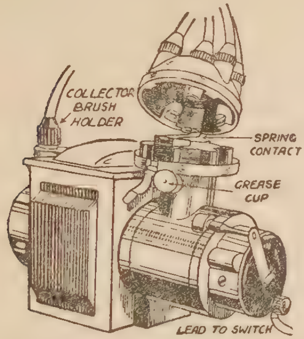


FIG. 210.—A typical Magneto with bevel-driven jump-gap distributor. This type of distributor is also used for coil ignition, and requires minimum attention.

Coil Ignition System.—In the coil ignition system a coil of wire is used to transform a tiny amount of current from the lighting accumulator to a voltage high enough to cause a spark to jump the gap at the plug points. A make-and-break and distributor similar to those used with a magneto are employed; when the contact-braker is " open " the low tension circuit is broken, and at the same moment the distributor closes the high tension circuit, thus causing the spark to occur at the plug points. The coil itself consists of a primary winding of wire over an iron core, a secondary winding of wire, which is wound over the primary winding, and a mica and tinfoil condenser. This simple piece of apparatus is placed inside a case made of ebonite or similar material. This coil unit may be fixed in any convenient position, such as behind the dash, above the charging dynamo or at any other convenient point; and because of this it is certainly more accessible than the dynamo. The part most likely to give trouble is the condenser, which can easily be

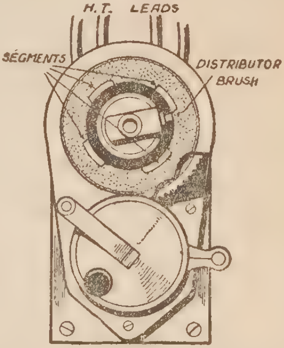


FIG. 211.—A Wipe Contact Distributor. Brush, and fixed contacts should be cleaned occasionally with metal polish.

detached for replacement purposes.

The contact-breaker and distributor are usually incorporated in the dynamo, unless this latter is belt-driven, in which case they are coupled at some convenient point to the engine. The leads for the sparking-plug, of course, issue from the distributor. It should be added that the current flowing in the secondary of a coil is negligible.

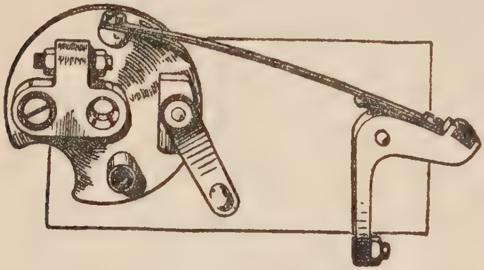


FIG. 212.—A typical contact-breaker, with rocker removed to show pivot and fibre brush.

Elements of the Magneto.—Briefly, the magneto comprises a permanent magnet with a pair of pole pieces, which form a tunnel in which runs an armature, consisting of a core built up of soft-iron laminations. On this core is first wound a few layers of thick insulated wire, and the commencing end of this wire is connected to the core. To the outer end of this wire is connected the beginning of another winding, which thus forms a continuation of the first; but in this case the wire, which, like the first, is also insulated is extremely fine, and it is coiled many thousands of times round the core. As it is in this winding that the high voltage current is generated, it is carefully insulated from the metal parts of the machine; a typical armature is shown earlier. These two windings are called the primary and secondary, respectively. At one end of the core is mounted a condenser consisting of a number of sheets of tinfoil separated by sheets of mica. Mounted on the end of the armature shaft is the contact-breaker, the action of which is similar to that of the coil already detailed. The other end of the secondary winding is connected to the brass slip ring fixed to the other end of the armature, and bearing on this slip ring is a carbon brush or collector. This brush collects or picks up the high-tension current generated by the rotating armature, and transfers it to the distributor, which is a sort of revolving switch distributing the current at the correct moment to the various plugs.

The contact-breaker (*see* Fig. 212) comprises a rocking arm with a platinum contact screw at one end. A spring keeps this in contact with another fixed platinum contact screw. Surrounding the contact-breaker is a cam ring which (in the case of a four-cylinder engine), has two small humps or cams formed on its inner surface; and as the other end of the rocking lever bears on this surface; it is obvious that the primary circuit will be broken twice in every revolution.

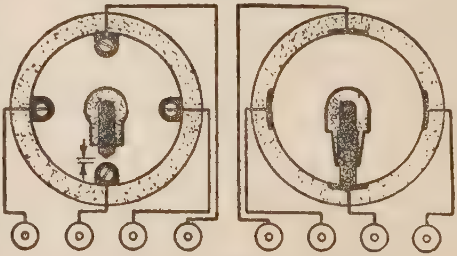


FIG. 213.—Carbon brush type of distributor (*right*), and (*left*) the spark-gap type.

IGNITION TROUBLES.—Faults in the ignition system become apparent in one of two different ways; either the engine is "rough" and pulls erratically, or starting is difficult or even impossible. In the same manner, the commoner faults can be divided up into two distinct classes. Electrical leakage (or partial short-circuits) may occur, or the opposite fault of bad electrical contact might be the source of trouble. In dealing with all ignition difficulties, it is well to bear in mind that the ignition system is simply an electrical circuit, and that it should be treated as such. Because of this it is very important that all insulators, such as the sparking plugs, their leads, and the distributor should be perfectly dry.

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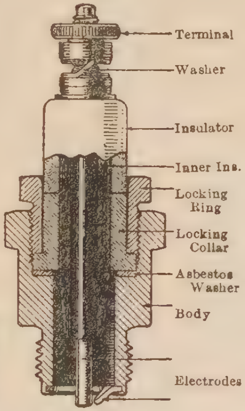
FIG. 214.—Detach the central plug electrode for cleaning.



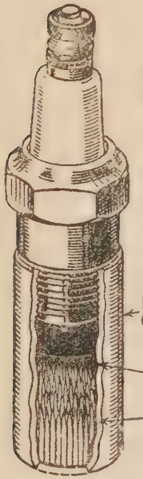


FIG. 215.—This sketch shows a useful type of plug cleaner which is on the market.

The most common kind of ignition trouble is that which causes the engine to mis-fire periodically, this trouble generally being more pronounced when the car is pulling hard. An actual mis-fire is easily detected by listening to the exhaust while the car is running, by noticing the sound of the engine itself, or by the "feel" of the car. If it is noticed that the car moves somewhat jerkily it is often safe to assume that the ignition system is at fault, although the possibility of the carburettor or fuel supply being wrong should not be overlooked.

Systematic Testing.—After it has been determined that the ignition is wrong it is wise to make a systematic test, since haphazard examinations will only prove to be a waste of time in most cases. The first thing is to find which cylinder is suffering, assuming that the fault is not more general. This can be done by allowing the engine to tick-over fairly slowly and then to short-circuit each sparking-plug in turn (as shown in Fig. 216). In doing this either a screwdriver or a hammer-head can be used, but care should be taken to see that contact is made to the cylinder block before the sparking plug terminal is touched; if this is not done there will be a danger of receiving a rather unpleasant shock.

If the plug is functioning correctly the engine speed should be reduced when its terminals are short-circuited, and there should be a change in the "note" of the engine. When the plug is faulty, however, there will be no change when it is put out of circuit.

In many cases it might be found that, although there is a distinct sign of "missing" when the engine is under load, every plug seems to be functioning correctly whilst it is "idling." If that is the case, a more thorough examination will have to be made and the method of applying this will be dealt with more fully at a later stage.

Locating the Fault.—Should it be found that one particular plug (or rather, cylinder) is at fault, a number of smaller tests should be made to trace the fault to its origin. First switch off the ignition and then remove the high-tension lead from the plug-terminal. After that the engine can be started again and the terminal on the lead held about ⅛ of an inch from the plug-terminal, care being taken to hold the lead by the rubber insulation. There should be a good, fat spark; if not, try moving the lead so as to reduce the gap. If a reasonably good spark is obtained it will be proof that the plug itself is incorrect, whilst the lack of a spark will point to the distributor.

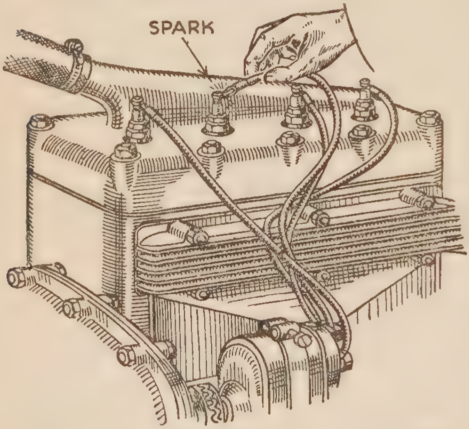


FIG. 216.—A useful test can be made by holding the high-tension lead about ⅛ in. from the plug terminal whilst the engine is turned by hand—there should be a good spark.

In either case the plug should be removed and the points examined. Should they be too far apart—test the gap with a suitable feeler-gauge, or with an ordinary visiting-card—they should be closed a little, whilst if they are touching or short-circuited by a piece of carbon or drop of oil, the remedy will be obvious. After making the adjustment the high-tension cable should be re-connected, the plug laid on its side on the cylinder head (its terminal should not touch the head), and the engine started up again. There should be a spark between the points if the plug is working properly. Even if there is, it is not a sure sign that everything is well, because conditions are entirely different when the spark-gap is in the open-air from when it is in the cylinder-head and subject to a reasonably high pressure.

Cleaning the Plugs.—If a spark cannot be obtained it will be understood that the plug is short-circuiting, and it must therefore be cleaned out. When the plug is of the detachable type the central electrode can be removed, as shown in Fig. 214, by holding the body of the plug in a vice and unscrewing the flange with a spanner. This could not be done on the road, of course, and in such circumstances it would be necessary to replace the vice with an adjustable spanner which can be held on the running-board with one foot while the spanner is worked by hand.

The wise motorist, especially if he drives a car which is past its prime, always carries a spare plug in the tool-box, and if this is done the work just described can be postponed until the car has been garaged again. Some plugs are not of the detachable type, and they can only be cleaned by soaking them in petrol and allowing them to stand for some time until some of the carbon deposit is dissolved. Alternatively it is possible to buy handy plug-cleaners similar to that shown in Fig. 215. These consist of a tubular metal container, whose end is threaded to receive a plug. Inside there are a number of fine, sharp " needles," so that after the tube has been filled with petrol it is only necessary to screw in the plug and shake for a little while. It might also be mentioned that several garages have recently installed small machines by means of which plugs can be thoroughly cleaned in a few seconds ; a charge of threepence per plug is usually made for cleaning.

Examine the Distributor.—When it has been ascertained that all the plugs are in satisfactory condition —and the ignition trouble still persists—the distributor should be examined. Should it appear that only a single plug is " missing," a careful examination should be made for slight cracks in the distributor-cover. Sometimes the crack is so thin that it cannot be seen by ordinary examination. In that case the engine should be started up and the bonnet nearly closed in order to cut out the light ; a spark discharge will then generally show where the crack is. The most satisfactory cure is to obtain a new distributor-cover, but in many cases a perfectly satisfactory repair can be effected by scraping clean the surface of the crack and making a small hole at the end nearest to the terminal. After that the cover should be dried thoroughly before the fire, or in a warm oven, and then given an application of shellac varnish.

It will often be found that, although the plug is quite in order and there is no fault with the distributor, one cylinder still mis-fires. There only remains one more possible source of trouble, this being the high-tension lead from the plug to the distributor. First make sure that it has not been chafed or burnt due to being too near to the cylinder-head, or other part of the engine. It is possible that the insulation may have been damaged with a result that the cable is short-circuiting, and this point can be checked (preferably in the dark) by watching for sparks between the cable and the engine. The next thing is to make sure that the ends of the wire are properly connected to the appropriate terminals. If there is any doubt it is wise to cut a short length of wire away from both ends and to fit new connecting plugs. Whenever a faulty cable is found it is better to replace it with a new one rather than to patch it up with insulation tape.

When the Engine Fails to Start.—The ignition troubles referred to above have all been of a very minor character, and it becomes rather more difficult to trace major faults, which, for example, make it impossible to start the engine. When starting is extremely difficult or practically impossible, a test should first be made to see if the necessary voltage is reaching the plugs. One way of checking this (but one which is not to be very strongly recommended) is to grip the terminal of one plug and to *slowly* turn the starting handle ; a distinct " kick " should be felt. Another method is to get someone to hold the end of a plug lead a short distance from the terminal, whilst the engine is " swung "—a spark should be seen if all is well (*see* Fig. 216).

If any single plug is defective it can be traced as explained above, but if there is no spark at any of them, entirely different tests must be applied, because there must be something wrong with the distributor or coil, when coil ignition is fitted, or with the magneto. With either kind of ignition the first test should consist of removing the lead from the centre terminal on the distributor-cover—this is the main H.T. supply lead. The bare end should then be held close to the cylinder-block or magneto frame (not close to the carburettor, however), and the engine again turned over (*see* Fig. 217). Sparks up to nearly a quarter-inch long should be produced when the engine is turned fairly briskly. When such sparks are obtained it is evident that the fault is in the distributor and the carbon-contact brush should be examined; this is clearly shown in the diagram (*see* Fig. 218), where it is being held close to the magneto. The brush should be quite free in its socket and the pressure of the spring behind it should be reasonably good. Also examine the metal contact point against which the brush presses and clean if necessary.

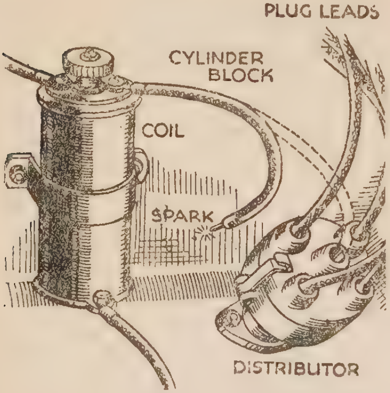


Fig. 217.—The coil and magneto can be tested by one of the methods shown above.

Weak Contact-breaker Spring.—If there is no spark from the main supply point the contact-breaker should be examined, looking to see that the points open and close correctly. Perhaps it will be found that they remain open due to the return spring being weak, or because the rocker sticks on its spindle. In either case the remedy is fairly obvious; either the spring should be replaced or bent slightly, or the rocker should be freed and the bearing-surfaces rubbed with a soft lead pencil. At the same time the spark gap should be checked with a feeler-gauge or with a worn sixpence. It should be noted that, in all cases, the spark gap should be rather wider than the plug points, otherwise satisfactory sparks will not be obtained.

If the platinum points of the contact-breaker appear to be badly worn or pitted they should be smoothed off with a magneto file, care being taken to make the flat surfaces quite parallel to each other.

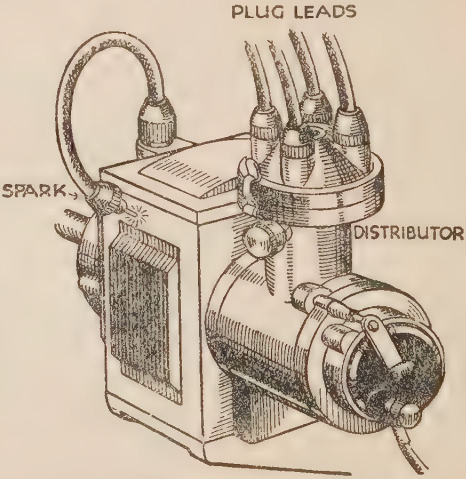


Fig. 218.—Method of testing magneto.

IMPELLER PUMP.—The water pump fitted to some cars for the purpose of driving water around the radiator cooling system.

IMPERIAL WIRE GAUGE.—The standard gauge for wires officially recognised in this country. It is more commonly referred to as the "Standard Wire Gauge."

See *S.W.G.*

INCANDESCENT IGNITION. —See *Catalytic Ignition.*

INCH.—A standard of measurement much used in British engineering practice. One inch equals $\frac{1}{12}$ foot, 2·45 centimetres, or 25·4 millimetres.

From the Latin, *uncia*, the twelfth part of a thing.

INDIARUBBER SOLUTION.—A semi-solid substance comprising mainly a solution of pure rubber in a solvent such as naphtha. Used chiefly as a cement for rubber, as, for instance, in the repairing of punctures.

INDICATED HORSE-POWER.—The power expended by the burning fuel mixture in driving the piston downwards. So-called because an instrument termed an "Indicator" can be used to measure or indicate the downward pressure on the piston.

Indicated horse-power does not account for the power lost by friction within the engine. Hence it does not represent the external power-output of the engine.

See *Brake Horse-power.*

INDICATOR.—In the restricted sense, as applied to engine technology, an "Indicator" is an instrument which automatically draws upon a card known as the *indicator card* a closed curve which indicates the variations in pressure within the engine cylinder due to the piston displacements.

The diagram so produced is termed the *indicator diagram.*

INDUCTION COIL.—See *Coil.*

INDUCTION PIPE.—The metal pipe or conduit which conveys the explosive mixture from the carburettor to the cylinders of the engine.

INDUCTION STROKE.—See *Suction Stroke.*

INDUCTION VALVE.—See *Inlet Valve.*

INERTIA.—The inherent tendency of a body to remain for ever in a state of rest or motion. A body in a state of rest opposes any external influence to set it into motion. Conversely, a moving body opposes any outside influence which tends to stop its motion or to change it.

INLET PIPE. — See *Induction Pipe.*

INLET PORT.—See *Port.*

INLET STROKE.—See *Suction Stroke.*

INLET VALVE. — The valve which admits the mixture of fuel vapour and air into the cylinder at regular intervals, the valve being operated by means of a cam.

INSPECTION LAMP.—The name given to a hand electric lamp, suitably provided with a metal guard, which is employed for inspection purposes within the bonnet of a car, under its wheels, or in other situations.

INSTRUMENT BOARD. — The wooden, metal or composition panel below the windscreen of a car upon which the registering and indicating instruments and, also, many of the car's electrical and mechanical controls are usually fitted.

INSULATOR.—A non-conducting material which serves to insulate or separate one conductor from another so that the electric current cannot pass between them.

From the Latin, *Insula*, an island.

INSURANCE.—Many motorists treat their insurance policies as just formal documents which are put away unread until the next renewal date. Actually, the policy is a very important factor in the insurance transaction, and it should carefully be studied when received. It contains the terms of the contract between the insured and the insurance company, and is the legal document which sets out what the insurance company are bound to do for the insured under various conditions.

The whole basis on which the policy is issued is referred to in the first clause of the agreement. " Whereas the Policyholder designated in the Schedule hereto by a Proposal and Declaration dated as stated in the Schedule which shall be the basis of the CONTRACT . . ." That proposal and declaration is the form which the insured filled in when he first applied to the company for insurance. It follows that this proposal form, must be filled in correctly or the whole contract becomes null and void. This is a very important point in insurance, and it cannot be too firmly impressed on the proposer that every question on the form should be considered carefully and a true answer given. There are cases where a proposer has filled in a proposal incorrectly, knowing full well that if he wrote the truth his proposal would not be accepted or would be subject to a higher premium. Such an offender is criminally liable, as he can be charged with obtaining his insurance under false pretences. Further, his policy becomes null and void when the true facts of the case become known and, should he have been involved in an accident affecting a third party, he would also be charged with driving a car without a current insurance policy in force.

Some insurance companies of no repute have refused to pay claims because the insured had made a slight error in filling in the proposal form. It has now been ruled, however, that a company cannot repudiate its liability if it is shown that the omission would not have affected the acceptance of the proposal.

Accident Records.—On completing the proposal on which the contract is based, it is very important that the section which deals with previous accidents should be filled up very accurately. This section is where the majority of prosecutions for obtaining insurance by false pretences lies. Naturally, the insurance company want to know exactly what kind of a man the prospect is in regard to accidents and, if it is found that he is a driver who is constantly in trouble, they may ask him to bear the first few pounds of every accident himself, or refuse his business altogether. At one time a man who had been involved in so many accidents that his proposal was refused, would put forward a proposal to another company in the name of his wife. The insurance companies became aware of this, however, and, where a wife applies for insurance, the husband's accident record is called for before the proposal is definitely accepted. It is also incumbent on the proposer to supply the insurance company with the name and accident record of any person who will regularly drive the vehicle, and failure to comply with this point may cause trouble should an accident occur when such a person is in charge of the vehicle.

Another section where trouble

can occur is the class under which the car is to be insured. There are three classes under which the private car is covered. These are as follows:

Class 1

Cars used for social, domestic, and pleasure purposes, also use by the insured in person in connection with his business or profession.

EXCLUDING

Use for hiring or for commercial travelling, or racing, pacemaking or speed testing, or for the carriage of goods or samples in connection with any trade or business, or use for any purpose in connection with the motor trade, or use by commission agents, insurance branch managers, surveyors, inspectors or collectors, wholly or partly for business purposes.

Class 2

Cars used for social, domestic, and pleasure purposes, also for the business or trade purposes (including transport of goods) of the insured, including use by the insured's employees for such purposes, but

EXCLUDING

Use for hiring or for commercial travelling, or racing, pacemaking or speed testing, or by commission agents wholly or partly for business purposes or use for any purpose in connection with the motor trade.

Class 3

Cars used for social, domestic, and pleasure purposes, also for any business or trade purposes of the insured, but

EXCLUDING

Racing, pacemaking, or speed testing, or the carriage of passengers for hire or reward.

Business and Pleasure.—It will be seen that a Class 1 policy covers the car simply and solely for pleasure purposes and for business purposes only in a very narrow sense. A doctor's car would be insured in Class 1, but anyone who calls for orders or who "travels" is excluded. The carriage of goods for any purpose is also prohibited in this class, though the insured may carry his own personal luggage, his shopping or similar loads, but must not, for instance, take the tomatoes he has grown to market. Class 2 covers such eventualities, but not commercial travelling or any purpose in connection with the motor trade. Class 3 covers the car for all purposes with the exceptions of those named.

It should be very particularly noted that if a car is used for a purpose for which it is not insured, the policy does not apply, and the third party insurance required by the Law is not in force. Should an accident occur, therefore, the owner and the driver would be liable to heavy penalties if a third party is injured. Great care should be taken that the car is insured in the correct class and that it is not used for any purpose which is not included in the policy. It should be noted that a car must not be used for carrying passengers for reward, unless it is specially insured for the purpose. Some owners occasionally use their cars for such a purpose, but they become liable for prosecution, unless they have insured their cars under a special hiring policy.

Travelling Abroad.—A comprehensive policy covers the policyholder against loss or damage to his car should he be involved in an accident in Great Britain, Northern Ireland, the Isle of Man, or the Channel Islands. Some policies apply to Great Britain only, but these are not issued by the large companies. Cover in the Irish Free State is only given at an increased premium. The protection also covers loading and unloading of the car incidental to its transport between ports in any of the places mentioned. The insurance company reserve the right to have the car repaired at their own expense or to pay to the policyholder an amount sufficient to re-imburse him for having the car repaired. The company also bear the reasonable cost of taking the car to the nearest competent repairers. Most policies cover immediate reasonable repairs to a car without the consent of the insurance company, provided that an estimate is posted to them before the work is commenced. This is an important clause, as it enables the insured to get his car on the road again in the minimum time.

Insurance policies do not cover wear and tear which have occurred in the ordinary course of running the car. Bursts and damage to tyres which occur in the ordinary way are also excluded, though a tyre damaged in the course of an accident will be paid for. This does not mean that a new tyre will be provided. The insurance company's engineer will estimate the value of the unexpired wear in the cover and make an allowance accordingly. In the same way, if a mudguard, already in a damaged state, is damaged beyond further repair, the company may not provide the full cost of a new one. On the whole, the insurance companies are very generous when repairs are required, and if the insured is honest and reasonable in his demands, they will meet him more than half-way.

"Comprehensive," "Third Party," and R.T.A. only.—A comprehensive policy covers the owner against third-party risks or an insurance may be effected which covers this risk only. The premium where third-party cover only is required is 50 per cent less than the full comprehensive cover or even less than this if the bare cover required by the Road Traffic Act of 1930 is required. The policy covers the holder against all sums, including the claimant's costs and expenses which are legally liable to be paid, should the policyholder cause injury to a third party or to property not belonging to him. It will be seen therefore that if an owner drives his car into his own gatepost, he cannot claim on the insurance company. Should he demolish his neighbour's gatepost however, the insurance company is liable to rebuild it for him.

Any amount of damages which a jury may award against the insured in respect of an accident caused by the car will be paid by the insurance company if he is adequately covered. The insurance company will, in many cases, conduct his defence if there is a chance of damages being awarded against him. Should he have insured his car in the wrong class, concealed his accident experience or some other vital facts, the insurance company may, quite rightly, refuse to pay, and in this case he may find himself with a judgment against him amounting to a very large sum.

A comprehensive policy also covers the holder against accident to himself and, in most cases, his wife. The amount recoverable is usually £1,000 on the death of the insured or his wife with smaller sums for vital injuries. This liability is usually limited to £2,000. Further, the policyholder can claim up to £10 or more for medical expenses in respect of an accident. The policy provides that these sums will only be paid where the injury is visible. This means that no claim can be made where a party avers that his nerves have been affected by the accident or that he is suffering from some complaint due to his unfortunate experience.

Most policies allow the insured to tow another vehicle so long as this is not done for reward, but do not hold the towed vehicle covered should an accident occur when it is attached to the insured's car.

Any policy is null and void if the car is being driven by a person who does not hold a driving licence. Some policies framed on more generous lines do not repudiate liability if the driver has held a licence and is not barred by a Court order from holding another. Similarly, should the driver represent that he has a licence and be allowed to drive the car by the policyholder, any damage sustained would be covered.

When Towing a Caravan.—A car may not tow a caravan unless it is specially insured for that purpose. An extra premium is charged but the amount is not very great.

When an accident occurs, the policyholder must give notice in writing to the insurance company at once and at the same time, if the car is damaged, he must state where it can be inspected. He must not make any promises to an injured party and is not authorised by the insurance company to settle any claims on their behalf.

An insurance policy concludes with a further reference to the original proposal form. "The truth of the statements and answers in the said proposal shall be conditions precedent to any liability of the Company to make any payment under the policy." Thus is the insurance company protected against fraud on the part of the insured. The honest motorist insured with a company of repute need have no fear that his just claims will not be met. The insurance companies take every possible step to protect themselves against dishonesty, but they do all in their power to give good service and protection to the average motorist. It is an economy to insure with a reliable company who will meet their claims without quibble. At any time a motorist may be involved in an accident which produces a third-party claim. If he is insured with an unreliable company he may find himself in the bankruptcy court. (See also *Motoring Law.*)

INTERNAL CLUTCH.—See *Reversed Cone Clutch.*

INTERNAL COMBUSTION ENGINE.—An engine which produces its motive power by virtue of the explosion or rapid combustion of fuel-vapour and air within a cylinder. Petrol, oil, and gas engines all operate upon the internal-combustion principle.

INTERNAL-CONTRACTING BRAKE.—A braking system fitted to some cars in which two hinged shoes covered with asbestos material contract on a metal drum attached to the revolving axle or shaft.

In some brakes of this type a flexible steel band takes the place of the brake shoes. Sometimes termed External Contracting.

INTERNAL-EXPANDING BRAKE.—The usual type of road-wheel brake fitted to modern cars. It comprises hinged members or "shoes" covered with friction-generating material. These expand within a closed drum which is fitted to the road wheels of the car.

INTERNATIONAL STANDARD THREADS.—See *Metric Threads.*

INTERRUPTER.—Term usually given to a form of automatically operated switch by means of which a low-tension circuit may be rapidly made and broken. The trembler of an ignition coil.

IRON.—See *Cast-iron, Wrought-iron.*

IRREVERSIBLE STEERING.—A term used sometimes to express the fact that although movement of the steering-wheel will affect the front road-wheels of a car, yet, by a special system of construction, the converse effect is prevented from operating. Hence the possible side-displacement effect of the front-wheels of a car striking an obstacle on the road, as, for example, a large stone or a brick, is not transmitted up the steering column to the hands of the driver.

ISO-OCTANE.—Chemical formula: C_8H_{18}. A colourless hydrocarbon liquid occurring in petrol. It has the same percentage composition as normal Octane (which see), but differs from the latter in the internal structure of its molecules. It forms a reference standard in the assessment of "Octane Numbers." (See *Octane Number.*)

ISOTHERMAL. — Having the same or an equal degree of heat. The term is one which is used in connection with heat-engine and energy calculations.

IVORINE.—A synthetic material composed of white opaque celluloid or white vulcanite, much used for the making of name-tablets, dials, tabs and other articles for car use.

J

JACK.—A device which, operating on a lever principle, usually by means of a screw or gearing, enables a heavy weight, such as the wheel of a car, to be lifted off the ground by means of hand-power alone.

JACK SHAFT.—Name applied to the shaft in some gearboxes which receives the engine drive. It is in line with but not continuous with the main shaft of the gearbox, the end of the main shaft being free to revolve within the jack shaft.

JET.—Name usually given to the inner tube of a carburettor. It has a narrow orifice through which a fine stream of petrol is drawn by the suction stroke of the engine.

JOULE.—The practical unit of work. It equals ten million ergs. After *James Prescott Joule* (1818-1889), the discoverer of the Law of the Conservation of Energy. See *Erg.*

JOURNAL.—The portion of a rotating shaft which runs in a bearing, as for example, the ends of the gearbox shafts which run in the gearbox bearings or the crankshaft journals which connect the crankshaft webs and work in bearings.

JUDDER: JUDDERING.—Term used to describe a peculiar vibration which is sometimes experienced when the brakes of a car are applied at low speeds.

K

KEROSENE. — American term applied to the paraffin oil obtained in the fractional distillation of crude petroleum. It is used chiefly as a burning oil.

KEY.—A rectangular piece or wedge of metal used to fasten a wheel to a spindle or shaft.

KEY-DRIFT.—A rectangular or square-ended steel punch used for driving keys in or out of the keyway.

KEY-SEAT.—See *Keyway.*

KEY SWITCH.—A switch which is operated by the insertion of a key which is afterwards removed, thus preventing the unauthorised use of the switch. Key-switches are frequently included in the ignition circuits of cars.

KEYWAY.—A slot or groove, usually half the depth of the key, which is cut into a shaft or a wheel-boss for the purpose of receiving a key.

The keyways in the shaft and boss are placed opposite to each other, after which the key is inserted and driven home by means of a key-drift, thus securing the wheel firmly to the shaft.

In the case of wheels transmitting much power, two or more keys may be used.

KILOMETRE.—A Metric System measure of length, used exclusively on the Continent.

One kilometre equals a thousand metres or nearly five-eighths of a mile.

KINETIC ENERGY.—The energy which is possessed by a moving body such as a car by virtue of its being in a state of motion.

The measure of the amount of kinetic energy possessed by a moving body is obtained by multiplying half its mass by the square of its velocity.

Distinguish kinetic energy carefully from *potential energy* which is the energy stored up in a body as a result of its position in space.

From the Greek, *Kinein*, to move.

KING PINS.—The metal pins or rods upon which the steering stub axles are pivoted.

KLAXON HORN.—See *Mechanical Horn.*

KNOCK: KNOCKING.—A peculiar hard thumping noise which is produced within the engine cylinders in certain faulty running conditions. It is often due to incorrect ignition timing. (See *Noises*).

KNOCKMETER.—An apparatus for determining the degree of "knock" or detonation created by a sample of fuel.

It consists of a "bouncing pin" fitted to the cylinder head of the experimental engine and making connection at its upper end to an electrical measuring circuit by means of which the amount of "knock" present within the cylinder is read off directly from a scale.

See *Bouncing-Pin Method.*

L

LACQUER—LACQUERING. — A transparent varnish used for coating upon metal surfaces in order to protect them from atmospheric action. Much used in the finishing of accessories and metal parts.

Originally lacquers were composed of a solution of shellac in spirit, but nowadays pyroxyline and other cellulose lacquers are much in evidence.

LAMINATED SPRINGS. — See "*Leaf Springs.*"

LAMINATION.—A metal or composition sheet which with other sheets of a similar shape, size and material forms a composite structure. Magnetic armatures, transformer frames, etc., possess laminated structures in order to reduce eddy currents generated therein.

LANDAULET.—From *Landau*, a carriage having a top which can be raised and thrown back. The term is used to describe a motor-car body possessing these features.

LAPPING.—A term which is used to denote in general, the rubbing or polishing of a metal surface, and, in particular, the operation of final reduction of a metal part to its exact required size by means of abrasive powders of varying grades of fineness.

LATE IGNITION.—See *Retarded Ignition.*

LATENT ENERGY.—Unreleased, stored-up or potential energy.

A gallon of petrol represents a supply of latent energy in a compact form.

LATHE.—A machine used for the turning and shaping of metallic and other objects. By means of it, also, nuts, screws, and other parts may be made.

Modern engineering lathes embody many ingenious devices and are responsible for some remarkable feats of construction.

LAW.—See *Motoring Law.*

LAY SHAFT.—A term used to describe any shaft which is parallel to another shaft and which revolves with it. For example, in a gearbox the shaft running parallel to the one which is driven directly by the engine is known as the lay shaft.

LEAD.—A connecting wire of an electrical circuit, as, for example, the battery leads, the high-tension leads, etc.

LEAD.—A heavy, bluish-white metal extensively used for the construction of accumulator plates. The metal forms many different alloys. It is the basis of anti-friction metals, solders and white metals. It melts at 326°C. Taking silver as 100, its electrical conductivity is about 8·5. Lead can easily be rolled into sheets, and it is made much use of in the provision of protective outer coverings for wires and cables.

LEADED PETROL.—Petrol to which a lead anti-knock compound (lead tetra-ethyl) has been added.

LEAD TETRA-ETHYL.—Chemical formula: $Pb(C_2H_5)_4$. A heavy liquid which possesses remarkable anti-knock properties. Mixed with other ingredients, such as ethylene dibromide, it is added in small amounts to petrol in order to confer its anti-knocking properties upon that fuel.

Generally, the dilution of anti-knock compound in petrol is of the order of 1 in 3,000.

LEAF SEPARATOR.—A chisel-like steel tool which is inserted between the leaves or laminations of a car-body spring for the purpose of removing dirt or placing grease therein.

LEAF SPRINGS.—Name given to the usual type of car-body springs which consist of a number of thin leaves or strips of spring steel clamped together. They are sometimes termed "laminated springs." See also *Suspension Systems.*

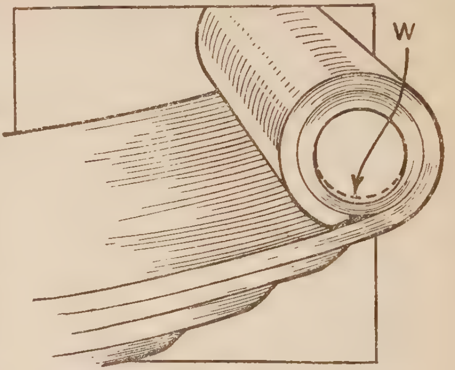


FIG. 218A.—This drawing shows how wear occurs in the spring-mounting bush.

LEATHER CLOTH.—Name given to a large class of materials used for car upholstery work, etc.

Leather cloth consists of a cotton base over which has been spread cellulose or cotton material, chemically treated, and dissolved in certain organic solvents. The base fabric is thus permeated with the solution, and, after the solvent has evaporated, hard but flexible cellulose is left within the fabric pores and on its surface as a shiny, weatherproof coating.

LEVEL.—A surface upon which there are no inequalities. The name given to an instrument which determines the amount of an object's deviation from a true plane.

Much used in mechanical construction, etc.

LIFTING-JACK.—See *Jack.*

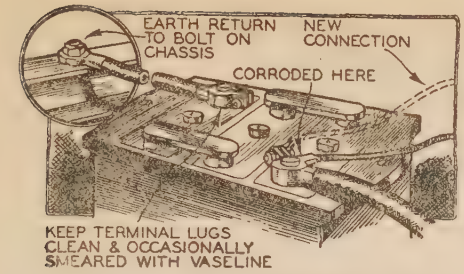

EARTH RETURN TO BOLT ON CHASSIS
NEW CONNECTION
CORRODED HERE
KEEP TERMINAL LUGS CLEAN & OCCASIONALLY SMEARED WITH VASELINE

FIG. 219.—This sketch shows various points that should be examined when a lighting failure occurs.

LIGHTING SYSTEM.—It is, fortunately, not very often that the car lighting system fails completely so that every light is extinguished. While driving a car which had the lighting accumulator housed in the tail, lights were first switched on whilst the car was travelling slowly in traffic, and everything appeared well until the engine was revved up for a change-down into second in order to make a quick get-away. As soon as the engine speed was increased the lights rapidly increased in brilliance until they went out completely—Why ? The answer is simple if it is remembered that the charging dynamo is connected to the accumulator, the latter also being connected to the lighting circuit. In other words, the dynamo, lights and accumulator are virtually in parallel. Normally the accumulator " absorbs " any charging current which might be in excess of the requirements of the lighting circuit, so that the voltage applied to the lamps remains reasonably constant. If, however, the accumulator becomes disconnected, the dynamo voltage increases rather considerably and the abnormally-high voltage developed is applied directly to the lamp filaments. The result is, naturally, that the filaments light up more brightly than usual and burn out if the voltage attains a sufficiently high value.

In the particular case mentioned above it was soon found that one of the connecting lugs had shaken loose from the accumulator terminal, so producing the result described.

The trouble experienced would probably not have occurred had it been noticed, before switching on the lights, that the dashboard ammeter did not show any " charge " reading. In the same way the difficulty would never have arisen if a few minutes had been spent occasionally in examining the accumulator connections.

Corroded Battery Connections.—A second complete lighting failure which is worthy of especial mention produced a very narrow " shave." In this case it was found—after much groping about and striking

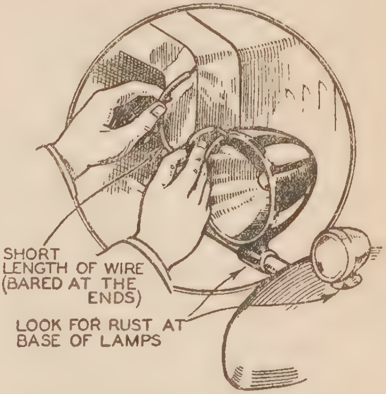

SHORT LENGTH OF WIRE (BARED AT THE ENDS)
LOOK FOR RUST AT BASE OF LAMPS

FIG. 220.—When it is considered that the earth return is defective a test can be made by making contact between the lamp reflector and some point on the engine or chassis.

of matches—that the (thinner) lighting lead connected along with the (thicker) starter-motor lead to the lead accumulator connector lug had corroded close to the end of the lug as shown in Fig. 219. Once this had been found it was only a matter of minutes before the end of the wire had been scraped clean and connected again by screwing it under the lug clamping bolt as shown by broken lines in Fig. 219.

Flickering Lights.—Another lighting difficulty which was experienced quite a short time ago was that of constant flickering of the lights; it generally seemed to be worse when travelling over a bumpy road, but this was not always the case. All battery and lamp connections were examined in a systematic manner, but the fault could not be found. When the car was standing still the lights were perfectly steady and it was impossible to make them flicker by rocking the car or shaking the battery leads, or, in fact, by any other means that could be thought of.

In the end it was decided that the only thing to do was to try the car on the road again and watch every point as carefully as possible. This time more luck was experienced, because, after a few miles, it was noticed that there was a faint smell of burning. The car was stopped and a "search" made for the smell; it was soon found that this was coming from underneath the car on the "off" side between the battery (carried under the driving seat), and the tail light. Very little time was required to discover that the wire—there was a single-wire lighting system on this particular car—from the switchboard to the tail light was short-circuiting to the chassis at one point, due to the fact that the insulation had been scraped away by constant rubbing. A short length of insulation tape put matters right but, so as to prevent any recurrence of the trouble, the wire was fastened more securely to the chassis member so that it could not swing about.

The "Earth-Return." — Some little time ago whilst passing through a North-Country town the writer was pulled up by a policeman because the near-side lamp was not alight. It was hoped to get away by promising to keep the head-lights on, but the policeman soon made it clear that this would not do since the light centres were not within 12 inches of the outside of the car. There was therefore nothing for it but to effect a repair. First a new bulb was tried—at least the side and tail-lamp bulbs were inter-changed—but there was evidently no fault in this direction. It remained to test the wiring. This was on the single-wire or negative-earth system in which the negative terminals of the accumulator, dynamo, lamps, horn, etc., are all joined to the chassis instead of being connected together by means of a second wire. First of all the wire passing through the wing into

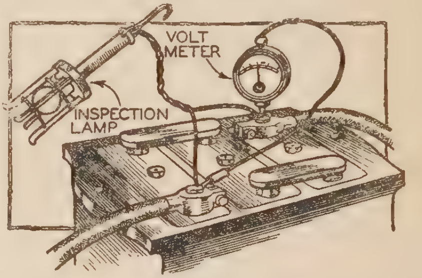


FIG. 221.—If it is suspected that the accumulator is at fault, it can be tested by one of the methods illustrated above.

the base of the side-lamp was waggled about in all directions to make sure that it had not broken at the point where it entered the lamp (this is a fairly common source of trouble which should always be looked for). Since this made no difference it was decided that the trouble was probably in the earth return. A length of flex is always carried in the tool-box so this was connected between the reflector of the lamp and the radiator shell (*see* Fig. 220). The lamp at once lit up, showing that the earth return was at fault, or in other words that the lamp-casing was not in electrical contact with the chassis. Further examination showed that rust had formed between the base of the lamp casing and the wing, so that it was only necessary to remove the lamp, scrape the surface of the wing and base of the lamp with the back of a pocket-knife blade to put the matter in order again.

A Simple Test.—It might be mentioned that, had the length of wire not been available a similar test could have been made by using the blade of a screwdriver. The edge of this would have been pressed through the enamel on the wing whilst the circuit would have been completed by touching the screwdriver against the edge of the reflector.

Failure of a tail light can be traced by exactly the same method as that described above, except that contact between the lamp reflector and the chassis would be made by touching the wire against the rear bumper bar or the dumb-iron, the latter being scraped bright at some convenient spot.

Systematic Trouble Tracing.—The examples of lighting failures given above will serve as a useful guide to the general method of locating faults in the electrical system, but a few more specific rules will now be given. In the first place it should be pointed out that, in locating any fault, it is particularly desirable that some system should be followed, otherwise there is bound to be considerable delay. Should the complete lighting circuit fail completely the first thing to do is to examine the fuse; this will probably be found to have " blown." If that is the case it is best to look for the cause before fitting a replacement, because if this is not done it is probable that the next one will burn out as soon as it has been fitted. Trace out the wiring from the various lamps to the switch-box and make sure that the insulation has not been damaged at any point. In this respect it

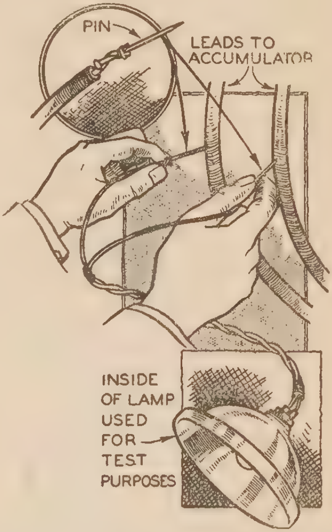

PIN
LEADS TO ACCUMULATOR
INSIDE OF LAMP USED FOR TEST PURPOSES

Fig. 222.—Tests at various points in the lighting circuit can quickly be made, as shown above. Contact with the leads is made by means of pins.

might be mentioned that the most likely place for such damage to occur is where the wires are bent at a sharp angle or where they pass through holes in the coachwork. Where the wiring is on the two-wire system (recognised by the fact that there is a double wire leading to every lamp) a short-circuit could only occur if both wires were bared of insulation and touching each other. On the other hand, if the car is wired on the earth-return principle a short can be caused by a single wire being bared and touching any metallic part of the chassis or body.

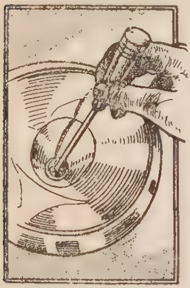


Fig. 223.— When any particular light fails it is a good plan to make sure that the spring plungers have not become jammed, thereby preventing contact with the tips on the lamp-base.

If there is no sign of a short-circuit the fuse may be replaced with a fair degree of safety, because it may have "blown" due to a temporary current "surge" which might never appear again. If the fuse goes again soon after it has been renewed it will be clear that there is a fault that has not been traced, and all wiring must therefore be again examined with greater care, whilst it might temporarily be removed from the clips which hold it to the chassis for closer inspection.

Tracing Broken Leads.—Should it be found, after all the lights have failed, that the fuse is still intact it will be evident that either the accumulator has become completely discharged or else a wire has broken or come adrift. Examine the leads to the accumulator and see that the terminal lugs are tightly clamped up and that the terminals themselves are clean (*see* Fig. 219). If the latter appear to be dirty or corroded the lugs should be removed, the terminals scraped clean, smeared lightly withv aseline and the lugs replaced. If there is then no improvement trace the leads from the battery to the switch-box and feel for breaks inside the insulation by kinking the leads at intervals. Where earth-return wiring is used make quite certain that the lead from the negative terminal on the battery to the chassis is unbroken and that the chassis contact bolt is not rusted or loose (*see* Fig. 219).

After attending to all the points mentioned it will be evident that, if the lights still fail to come on, either the battery is down or the switch is faulty. The latter fault is most unlikely, but it can be examined by removing the switch-box cover, when any fault will almost certainly be indicated by an obvious oxidised appearance of the copper switch contacts. The battery can be tested by means of a voltmeter or by connecting a lamp between its terminals as shown in Fig. 221. The lamp might conveniently be an ordinary inspection lamp, or it might be the "internals" of a side light as shown. If the car has earth-return wiring one connection will be made to the reflector, of course.

Should the lamp light up, a second test may be made by connecting it between the two battery leads near the switchboard, or, in a single-wire system, between the wire and the car chassis. In this case it will be found most convenient to attach two pins to the ends of the short leads on the lamp-holder, as shown in Fig. 222, so that connections can be made without having to strip the insulation off the normal circuit wiring; the pins are simply pushed through the middle of the respective (insulated) wires.

When only a single light fails and it is determined that the bulb itself is not at fault it is a simple matter to apply the same tests as those just described. This time, however, the tests will be carried out only on wires (or that wire) leading from the lamp to the switch-box. Whenever it is found that the lamp used for testing lights up when it is connected to a particular point in the wiring it will be known that a break occurs somewhere between the point at which the test is being made and the lamp, so that the simplest way to effect a repair will be to cut off the connecting wire and attach a new length, soldering the joint and carefully covering it with insulation tape. Do not use any odd piece of wire that might be to hand (except as a makeshift measure) but obtain a length of the proper material, or otherwise use a piece of vulcanised rubber cable which will last indefinitely provided that it is not in such a position that oil is likely to fall upon it.

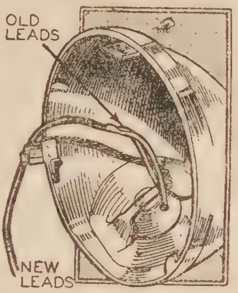


FIG. 224. — When fitting new leads to a lamp it is best to attach these to the old ones, so that the latter may be used to pull them through the mounting bush in the base of the lamp.

Although all the above remarks have been in connection with curing faults it is well to remember that prevention is much better and that an occasional examination of the wiring will be repaid by trouble-free service. Whenever a wire shows signs of perishing or the insulation has been chafed it should be replaced at once.

The usual lighting trouble is that of a burnt-out filament, and it is hence always wise to carry spare bulbs. Remember that in some cases the dashlight can be used as rear light or wing light. Frequent blowing of the filaments usually indicates trouble with the cut-out.

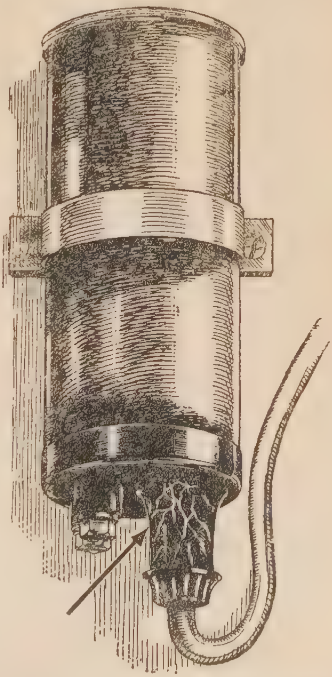


FIG. 224A.—A typical Coil, showing how cracks may be formed on the nose through accumulation of metallic dust.

LIGHTING AND STARTER SYSTEM.—Lighting faults occur at the following places: the battery terminals, under the mudguard when sidelamps are mounted on them, wherever a lead bears against any part of the vehicle, at soldered joints and earth connections. There are two systems of car wiring used to-day. The earth return system in which only one wire is carried to the lamps, the second connection, usually the negative, being earthed to chassis frame and providing a common lead for all of the electrical equipment. The other system is the twin wire, in which two wires pass to the lamps and other electrical equipment. The latter system rather complicates the wiring, but there can be no question but what it is the best, for there are no high resistance joints as in the earth return systems to cause a voltage drop.

The Usual Lighting Defects.—There are five kinds of faults that may occur in the wiring of a car, namely, an open circuit, an earth, a short circuit, defective insulation, or defective connections. You can test which system your car is wired on by inspecting the bulbs in the lamps; the twin wire or insulated return system will have double-pole bulbs, and the other single-pole bulbs. In the event of failure in the lighting system it is as well first to inspect the terminals on the battery, and to open the vent plug to make quite sure that there is no leakage in the casing, as explained previously.

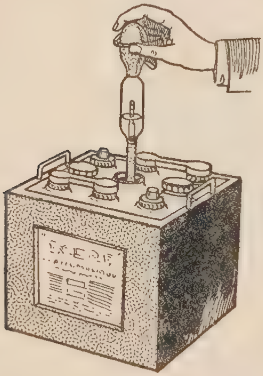


Fig. 225.—Frequently test the Battery with a Hydrometer.

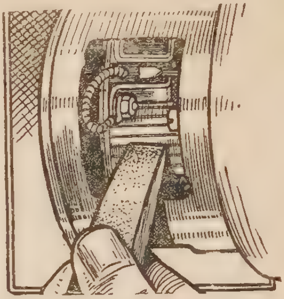


Fig. 226.—Showing the Inspection Cover of the Dynamo removed. The commutator should be cleaned and the brushes inspected occasionally.

Next examine the bulb. Occasionally the connection between the filament and the terminal breaks inside the brass cap. Test the lamp socket and prongs; sometimes a prong will stick, thus preventing contact with the bulb. More usually lamp failure is due to defective insulation at one of the points named. If the bulb frequently burns out, this may be due to using bulbs of the wrong voltage, a defective contact in the dynamo battery circuit, or the cut-out contacts do not close properly. When the lamp lights intermittently this may be due to a loose battery connection, or loose connection to the lamps, or even a wire which is nearly touching and not making good contact. Sometimes the lamp-holder-prong springs are weak or broken.

Electric Horn Defects.—The usual trouble with an electric horn is either defective brushes or a dirty commutator. The commutator should be cleaned with petrol, and any carbon scraped out between the segments. The brushes may be stuck up in their holders, or worn so low that they do not make good contact. This is obviously a case of renewal. If the horn fails to work after attention to these details, the trouble must exist in the wiring to the horn. Check this by disconnecting the leads and holding them in contact with the two contacts on a bulb. If this lights when the horn button is pressed, the motor itself is probably burnt out, in which case it should be sent back to the makers. An adjustment is usually provided so that the note of the horn can be varied from low pitch to high pitch.

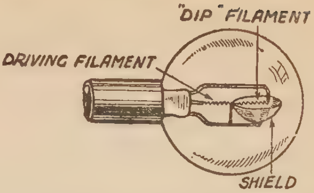
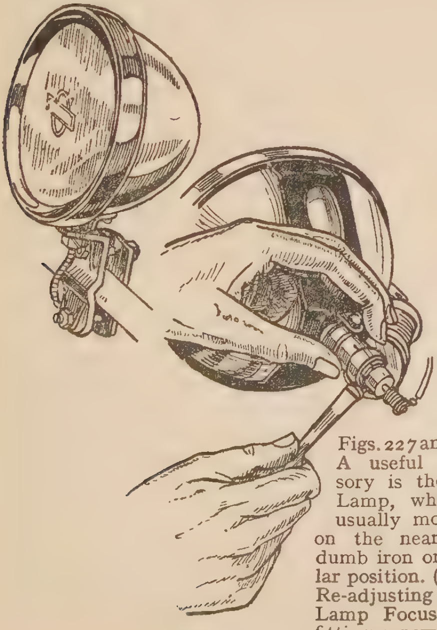


Fig. 229.—A Double Filament Bulb.

The Cut-Out.—The cut-out is often responsible for trouble. To test whether this is functioning satisfactorily, start up the engine, remove the cover, and get an assistant to rev. the engine up whilst you watch whether the cut-out contacts close. Now switch the engine off and observe whether the contact opens automatically. If they do, remove the fuse cover, and notice whether the fuse has blown. If it has, you will observe that new fuses are attached to the terminal box, and a new piece should be bent down and screwed into contact. Failure of the cut-out does not necessarily imply that the trouble is there, it may be due to a defective dynamo, and the cover of this should be removed, the commutator cleaned, the segments scraped clean, and the brushes inspected for wear. Quite often they stick up in their holders, and when released and cleaned the trouble vanishes. If the leads from the dynamo are removed for any reason, make quite sure that they are replaced on the correct terminals, otherwise the battery will discharge back through the field winding of the dynamo when the engine is switched off. This will



Figs. 227 and 228. A useful accessory is the Fog Lamp, which is usually mounted on the near side dumb iron or similar position. (*Right*) Re-adjusting the Lamp Focus after fitting a new Bulb.

be evident by the ammeter showing a discharge when the engine is switched off.

Dynamo Overcharging.—This is usually due to one of the brushes becoming stuck up in its holder or making faulty contact. Sometimes, however, it is due to the solder on the commutator having become melted, due to overheating, a condition which usually obtains when the dynamo has been overcharging for a considerable period. (*See* Fig. 234.)

Adjusting Output of Dynamo.—It is possible to adjust the output of a dynamo by slacking off the two screws securing the frame carrying the brush holders and brushes, and slightly rocking it until the desired out-put is obtained. The engine should be revved up to a speed corresponding to a road speed of about 30 miles an hour when checking any adjustments of this sort. The amateur cannot carry out any repairs to the dynamo, other than those indicated. Sometimes the races are badly worn, allowing the armature to become out of centre. New races can be fitted at most garages. If, after attention to these points, the dynamo still refuses to charge, the field winding has either burnt out or the cut-out is faulty. In this case apply the tests already mentioned.

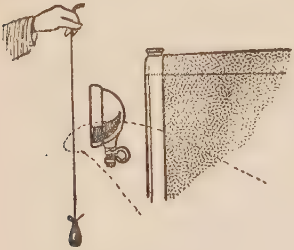


FIG. 230.—Testing if Head Lamp is Vertical.

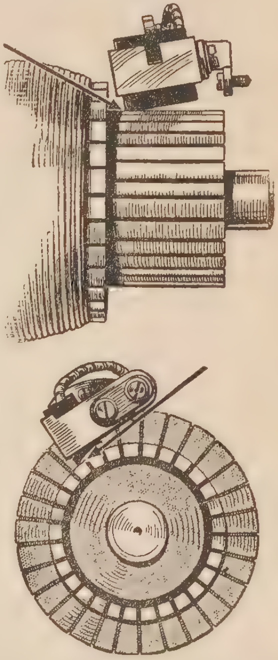
Dynamotor Faults and Remedies.—The same faults and remedies as for the separate dynamo and starter unit are applicable. The following additional faults may occur : Rapid acceleration or deceleration may loosen the armature core, resulting in broken commutator connections and open circuit in the armature winding. The coupling bolt or laminations may be sheared through similar causes, and the drive between the dynamotor and the engine disconnected. The teeth of the dog which is engaged by the starting-handle may become worn or broken, so that the engine cannot be turned or started easily by hand. Dynamotors are dual-purpose machines, designed to combine in a single unit the functions of both dynamo and starter. Only one drive is required to transmit the power developed by the dynamotor, to the engine, and to drive the machine by the engine.

The Starter Motor.—One of the commonest troubles with the starter motor is that in which the pinion jams in mesh, so that the armature is driven by the engine. This is usually due to the starter motor shaft being out of line or to the gear mesh adjustment being incorrect. To release a jammed piston switch off the engine, put the gear lever into the top gear position and push the car backwards. The brush gear and armature should be cleaned exactly as with the dynamo, and sticking brushes, broken brushes, the brush spring broken or displaced are other troubles which should be looked for. These are really the only defects which can be remedied by the amateur. (Refer to *Starter Motor* for guidance as to other parts needing adjustment and attention).

Dynamo Failures.—As a safeguard against dynamo failure, nearly every car is provided with an ammeter. This instrument records both the current flowing from the battery and the dynamo. If this meter is disregarded, then the owner will suddenly find himself without any charge in his battery although the ammeter has been, for some time perhaps, giving him ample warning.

When a car is taken over, the position the ammeter pointer takes up when the dynamo is charging without the lights running should be noted, the same when the lights are burning should be noted, as also the difference between " Half " and " Full " charge. It does not matter if the ammeter is accurate or not as long as the relative positions are memorised. One day the owner will see a difference, and a few days after a greater difference ; thus the ammeter is informing him that something is happening somewhere. Perhaps the owner has discovered there is no "half-charge," therefore he should immediately take steps to find the reason why. A leak may have been set up somewhere cutting out that portion of the circuit and, should another leak start up during that time the car may come to a standstill. Leaks denote a deterioration in the wiring that is likely to continue until drastic remedies are forced upon the owner when he least wishes them to be carried out.

A Disregarded Warning.—If the average motorist went to a reliable auto-electrician immediately after such happenings, dynamo repairs would be down to quite one-sixteenth of what they are later. As an illustration we will assume that the pointer has flickered for perhaps some twenty miles, and for the sake of argument we will assume it has been caused by a sticking brush. Suddenly the pointer steadies and the ammeter registers as before the episode. Some days later the dynamo fails entirely, and an expert is called in. Politely he tells the owner that a new armature, at £2 10*s*., will be required, the fitting and testing of which will be another 17*s*. 6*d*. Let us try to fathom this so-called mysterious and excessive expense. When, at the commencement of the journey, the brush stuck up through dirt and grease restricting movement in its guide, considerable heat was generated through sparking between brush and commutator. Whilst



FIGS. 231 and 232. — Exaggerated views of imperfectly bedded brushes which will cause intermittent charging, or cessation of charging.

this heat softened the grease and permitted the brush to resume its correct duty, it, at the same time, softened the brush-tensioning spring, thereby permitting further sparking and heating after a prolonged run. This heat, in its turn, melted some of the solder securing the armature windings to the commutator bars, thus raising the resistance and causing yet more heat. Eventually the heat broke down the armature insulation, and there was complete failure, because the ammeter flicker was not attended to at the first opportune moment.

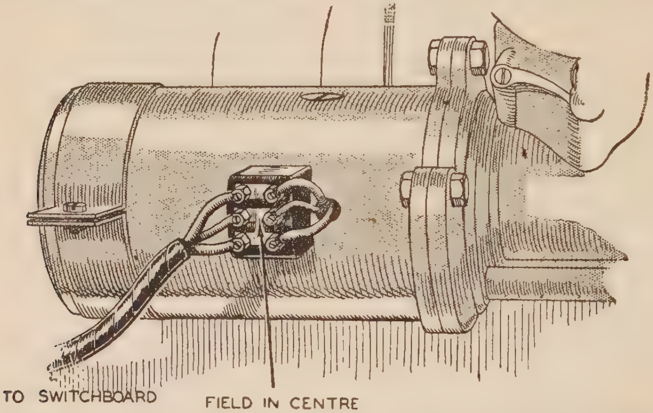


FIG. 233.—The terminal block on the dynamo. The field terminals are in the centre of this insulated block.

Inspect the Commutator.—The cover from the end of the dynamo should be periodically removed and the commutator inspected; the wear on the brushes observed, likewise the tension of the brush springs. If you have to touch any wires, see that they return to the same place as it is quite easy for one, or more, to be pushed down and the insulation ground off by the rotating armature. A disturbed wire may even touch the cover, when that is replaced, and cause failure. Look for small specks of solder that may have been thrown from commutator bars. If taken in time the armature can be saved, and at the same time the electrician will remedy the fault that caused the trouble.

Many burn-outs are caused by the owner advancing the "third" brush beyond its correct point. This brush should only be adjusted by an expert, this section being written for the owner who is not an electrician. Often this third, or current regulating brush, is held in position by screws on the end-plate of the dynamo. If these screws are indiscriminately loosened, there is a likelihood that the "main" brushes will also move. After this anything might happen to the machine, as it is a well-known fact that car dynamos in tip-top condition generate considerable heat, even when correctly adjusted. Any mal-adjustment will increase that heat to the point of destruction. Should the owner get the brush-gear mixed up, either by incorrect movement or incorrect connections, he should at once obtain advice, if he wishes to retain the dynamo as a useful article.

If the owner fits new brushes and has no means of bedding them in, either with fine glass-paper or pumice powder, he should allow them to settle down, and not expect good performance until they have done so. If there is much sparking, the offending brush must be removed and the high places removed. Always replace the brush the same way round, and see that the " pigtails," as they are called, are secure in the brush itself and tight under the terminal screw.

Ball-races carry the armature-shaft, and when fitted are packed with " high-melting-point " (h.m.p.) grease. This is sufficient to keep the bearing going until the periodic overhaul. Soft grease, or oil, will ruin the dynamo by getting all over it, spoiling the insulation, gumming up the brushes, and generally attracting all the dust that should have passed it by. Keep the oil-can away, but attend to the dynamo, at least every six months, as the h.m.p. bearing-grease will last that time without attention.

Field and Armature Wires.—Many dynamos have a terminal block screwed to the carcase, which at times carries the half-charge resistance coil. Both field and armature wires are led out to this block, where they are connected to the wires from the switchboard and cut-out. Sometimes a heavy-handed mechanic has turned the screw too tight and formed a spade on the end of the leading-in (or out) wire. After a time the small spade will break off and the dynamo ceases to charge the battery, but, unless it is the field wire, the dynamo may still be generating, and will burn up if not properly disconnected. As soon as the ammeter ceases to record, the owner should seek advice, and, if he knows nothing about the principles of electricity, he should proceed slowly, so as not to overrun the dynamo and cause damage. In many instances the fuse does not protect the dynamo from this fault, only the full-charge being governed by the fuse. It has, however, been remedied in the latest machines. Get to know which is the field wire and disconnect it when in doubt.

At times faults of a mechanical nature develop in the armature. They can only be overcome by a technician, and even then he must be a first-class electrician to effect a remedy. A bared wire may touch the frame, causing an " earth," or touch another bared wire, causing " short circuit." Either will lead to excessive overheating. A broken wire in the armature will cause an " open circuit," and be shown by excessive sparking and blackened and flattened sections of the commutator. The output will be low, and cannot be increased. It is a job for the specialist.

The Copper of the Commutator.—This being softer than the mica segment insulation, wears more quickly. The sign is fluctuating charging, slowness in cutting in, and perhaps not cutting in at all. There will be sparking. Another sign of this trouble will be failure to charge until the points of the cut-out are closed with the fingers. This is bad practice, but a test nevertheless. If the speed of the engine dies down and the cut-out points open and will not close again, the test is practically proved, although there is an exception to every rule.

The dynamo should be taken adrift, the commutator turned up in the lathe, and the mica insulation cut away until just below the surface of the copper. The commutator should then be polished. Look around the segments with a magnifying glass to see if there are any stray slivers of copper between the segments. This job needs skill, and should not be tackled by a novice.

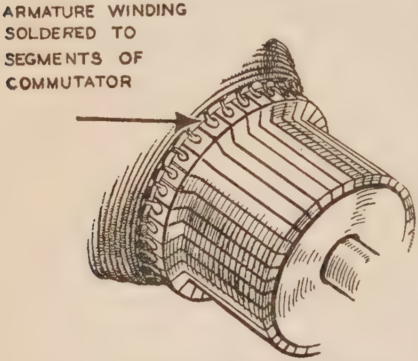


FIG. 234.—Risers of commutator, where the heat may melt the solder securing the armature wires.

A caution is to see that one always gets the right brushes for the particular type of dynamo. Correct performance depends on both the conductivity and hardness of the brush. If the conductivity is poor, or the brush soft, trouble will arise after even a few miles of use. There is no one like the maker to know the requirements of his own machine. A few pence more means longer life for the brush and less attention.

LIGROIN.—Name denoting a light petroleum of boiling-point 800-120s°C. It enters into the composition of commercial petrol.

"LIMIT OF LIGHT RUNNING."—A term used to describe the speed at which all the work done within the cylinder of a free-running engine revolving at high speeds is absorbed in engine friction. The limit always occurs at a point of speed considerably above the maximum output speed of the engine.

LITRE.—The Metric System unit of volume or capacity. It is employed for denoting the cylinder capacities of car engines.

One litre equals 1,000 cubic-centimetres, 1·75 pints, or 0·22 gallon.

LITTLE END.—The upper end and bearing of the connecting-rod at its point of connection to the gudgeon-pin of the piston.

Synonym : *Small end.*

LIVE AXLE.—The rear driving-axle of a car. An axle which rotates within a stationary axle-casing.

LIVE WIRE.—An expression used to denote a wire carrying a current.

LOAD.—Technically, this expression denotes the useful resistance which is set up against the motion of a vehicle or machine, thus giving a measure of the work being performed by the machine.

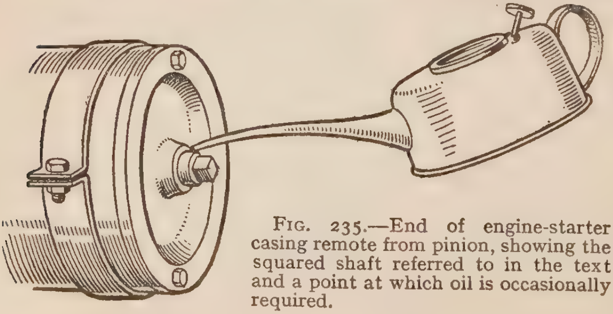


FIG. 235.—End of engine-starter casing remote from pinion, showing the squared shaft referred to in the text and a point at which oil is occasionally required.

LUBRICATING SYSTEMS.—We have seen in an earlier section that the oiling system, as far as the engine is concerned, is entirely automatic. Most cars to-day should do at least 1,000 miles to the gallon of oil. When the car has covered about 15,000 miles, however, the oil consumption increases, and unless attention is given to the pistons and bearings, the engine rapidly reaches a stage when the oil bill is greater than the petrol bill. It is very seldom indeed, that the oil pump itself goes wrong. A dashboard gauge or button is usually provided which indicates whether the system is working or not. If a gauge is fitted it should register a pressure of from 5 to 10 lbs. per square inch. Immediately this gauge fails to show a reading or the button on the dash fails to extend, the first thing to do is to examine the dip-stick and ascertain that there is oil in the sump. If the dip-stick reveals a correct supply therein, and an inspection of the oil-pipe to the gauge fails to reveal a fracture, examine the drain-plug, and make quite sure that there is no leakage there. If these points are found to be correct, the pump has broken down. This can only be inspected by removing the sump, and there is very little the amateur can do to put matters right.

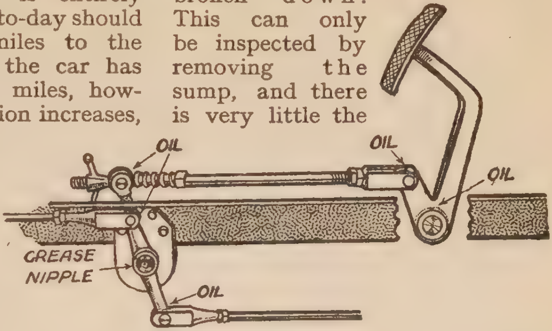


FIG. 237.—Points that are often neglected—Spindles, Yoke-ends, etc., of Brake Mechanism.

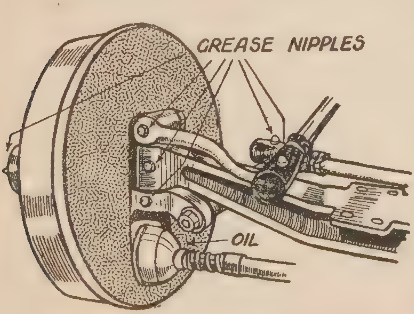


FIG. 236.—Typical Front Axle Assembly' showing Grease Nipples.

Excessive Oil Consumption.—Almost invariably excessive oil consumption is due to one of the following causes. Worn pistons, worn rings, piston rings stuck up, or worn bearings, and such should be attended to without delay, for the cost of the renewal will be more than saved on the reduced amount of oil used, quite apart from the gain in power, which new pistons and rings will give. When the engine is in this worn state it usually badly overheats. Information has already been given in an earlier chapter on the methods of examining the pistons and rings and their replacements.

Drain the Sump frequently.—A lot of unnecessary wear is caused in an engine by failure on the owner's part periodically to remove the sump after draining all the old oil from it. Oil after a time loses its nature, however good the quality of it, and a certain amount of grit becomes mixed with it, which acts as a lapping compound, wearing away the piston and cylinder-walls. It is wise about every three months to remove the sump and the gauze above it, and thoroughly brush this with an old brush in a bath of paraffin. Opportunity can be taken when this has been carried out to inspect the big ends and the pistons, as well as the oil pump and the cam-shaft. It is very unlikely that the oil gauge itself will break down. If this is suspected for any reason, disconnect the oil pipe from it, and observe whether oil flows from it when the engine is running. Trouble may arise in the pressure release valve, which is usually fitted on to the side of the crank-case. This should be removed, the spring taken out, and the ball valve examined to see if this is stuck up. Figs. 236 to 238 indicate oft-neglected parts, which should be regularly lubricated. (See also *Engine Lubrication.*)

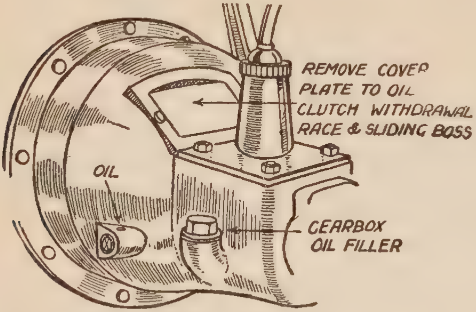

REMOVE COVER PLATE TO OIL CLUTCH WITHDRAWAL RACE & SLIDING BOSS
OIL
GEARBOX OIL FILLER

FIG. 238.—The Clutch Mechanism should be oiled regularly, and Gears topped up with oil occasionally.

LUGS.—The cross-connecting bars attached to the terminals of an accumulator battery.

M

MACADAM.—Term applied to denote a road surface composed of small broken stones suitably bound together, so as to form a smooth surface.

From *John Loudon Macadam* (1756-1836), a surveyor, who first introduced the method.

MAGNETIC SPEEDOMETER.—A type of speedometer in which the speed indication is obtained by means of the rotation of a cup-shaped permanent magnet, which tends to draw round with it a metal cover or armature against the tension of a suitable spring. To this armature the speed-indicating needle is attached.

MAGNETO.—A special form of dynamo comprising an armature, which revolves between the poles of one or more permanent magnets. It is employed in many car engines as a generator of high-tension current for ignition purposes. (See also *Ignition Systems.*)

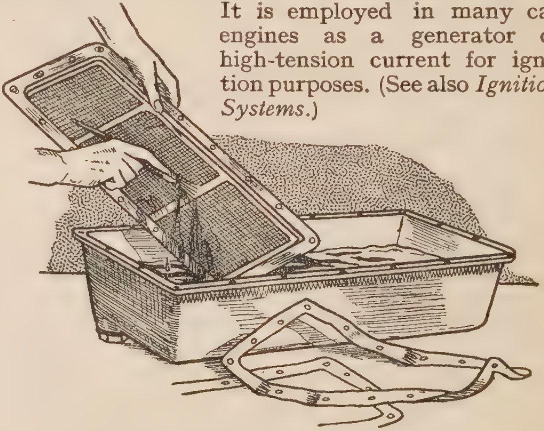


FIG. 239.—Cleaning the Gauze in the Sump.

Troubles.—Few drivers know much about their magneto. They have vague ideas that there is a primary and a secondary circuit, an armature, lines of force, a condenser, and the like. Perhaps it is just as well not to bother one's head about these things. A knowledge of the theory and working of the magneto may be interesting, but it is of no more practical use than the knowledge, to a wireless "fan" of how his valves work. The cases are similar in that should either the wireless valve or the internal parts of a magneto go wrong, nothing immediate can be done about it; they vary in that the valve is scrapped and replaced, whilst the magneto is sent to the works for repair. Fortunately, however, the working parts of a magneto do not often give trouble, and when the magneto is suspected it is usually what may be called the externals which are at fault. The externals comprise the contact breaker, and everything to do with it, the slip ring, carbon brush, and the high-tension lead.

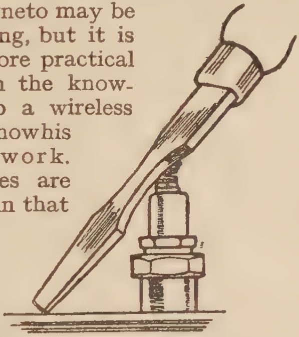


FIG. 239A.—Testing the Plug by shorting with a screwdriver.

Preliminary Tests.—A magneto differs from other parts of a car in that a superficial examination does not often reveal whether or no it is at fault. If there is petrol in the carburettor and the jet is not choked, nor the float punctured, one may dismiss the carburettor as O.K.; whilst if the valves do not operate, or there is no compression at all, the trouble is definitely located to the engine. But the fact that a magneto is giving a spark is by no means proof that it is in proper working condition.

The reason for this is that it is impossible to see inside the engine, and that the only test of a spark must be made outside. The usual way is to detach the sparking-plug, lay it on the cylinder or crank-case so that the body is "earthed," but the terminal isolated, revolve the engine, and watch for a spark at the plug points. This is a usual and simple test of both magneto and plug, the usual method of testing the magneto alone being to hold the high-tension lead about one-eighth of an inch from the cylinder, and see if a spark jumps the gap when the engine is revolved.

External Spark not a True Guide.—These tests, if unsatisfactory, locate the trouble to the ignition system, but even if a good spark is shown, or a healthy shock received, it is no sure proof that the magneto is O.K. The reason for this is that current which will jump a gap under atmospheric pressure will, if there is any fault or leakage in the magneto, return by some other course when the plug points are subjected to the

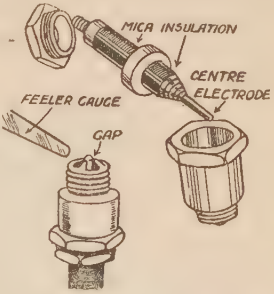


FIG. 240.—Testing the Plug Points with a Feeler Gauge, and dismantling a "Sooty" Plug for cleaning.

comparatively high pressure of the engine's compression stroke. This is because there is a very much greater resistance to a spark under a pressure of, say, 70 lb. than there is in the atmosphere (14·7 lb.). It is a point which is by no means generally understood, and most drivers will say that the magneto is "all right" provided that they see a spark at the plug points when carrying out tests under atmospheric pressure. Magneto troubles have another peculiarity—they seldom occur when the engine is running, unless in the form of slight misfiring. More usually, however, the machine will run perfectly so long as it is going; after a stop, however, it will be impossible to start. Let us run through the magneto failures which may be rectified, realising that serious condenser trouble or a broken winding are beyond the scope of the ordinary driver.

The engine will not fire; it is turning over freely, has a good compression, the valves are not sticking; there is a head of petrol at the jet; the magneto is timing O.K.

Some Possible Faults.—First of all remove the plug and fit a new one. (A new spare sparking-plug should always be carried.) If it still will not go, the magneto itself is obviously the trouble. It is interesting to check the plug for sparking, for it is encouraging to see a spark at the point, even if it does not serve much useful purpose. Now turn to the high-tension lead.

The High-Tension Lead.—It is quite possible that this is not making proper contact at one end or the other. Usually, the plug end of the high-tension wire is squeezed into a brass clip. Very possibly the wire has frayed through and broken, as shown at terminal connection. Or, again, it may be broken or making poor contact at the other or carbon brush end. The fact that a spark has been seen at the plug points does not necessarily prove that the wire is O.K., for the miss may be an intermittent one, and in certain positions of the cable there may be perfect contact, whilst in other positions there may be no contact at all. Pull at each terminal and satisfy yourself that there is a proper connection.

The Brush Holder.—Remove the brush holder carefully, making sure that the little brush does not drop down into the magneto. This brush bears on the smooth brass slip ring, and collects the high-tension current from it. The brush should be a springy fit in its socket, and should be quite dry and clean. If it is oily (a frequent cause of trouble) it should be washed in petrol. This, however, is not sufficient, for it has collected its oil from the slip ring. Therefore poke the corner of a piece of rag down the hole exposed by the removal of the brush holder, and turn the engine, so that the oil on the circumference of the slip ring is transferred to the piece of cloth.

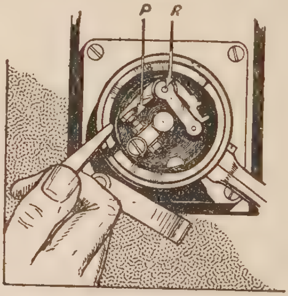


FIG. 241.—Testing the contact-breaker gap (P). R is a fibre bearing which should be free.

Damp.—There is only one more possible cause of trouble in this department—damp. If the brush holder is wet, or damp, the high-tension current will travel along the moisture and return through the body of the magneto. This is a very frequent cause of a magneto giving an apparently good spark, and yet failing to fire the charge. Electric current always follows the easiest path. When the plug is exposed, the easiest way is across the plug points; when, however, these are subjected to engine compression, the damp brush holder offers less resistance, and the current therefore follows the path. The remedy is, of course, to dry the brush holder and the socket into which it fits. Some magnetos have brush holders of the waterproof type, whilst others are often fitted with felt washers. If this washer has been saturated, the current will shoot through it. If the brush holder is not a good fit, it allows damp to creep along the washer and thence to the carbon brush. When everything is dry, the magneto works perfectly.

The Contact Breaker.—If all the points are in order—and they take a few seconds only to check—but still the engine "doesn't go," turn to the contact breaker. There are several types of contact breakers, but they all work on more or less the same lines, a standard pattern being adopted by most makers The rocker arm of this may be sticking on its fibre bush. Many drivers look to this point before turning to the high-tension wire, and this is quite a good idea. The suggestions in this section are, however, made methodically, the actual order in which they are carried out resting with the driver.

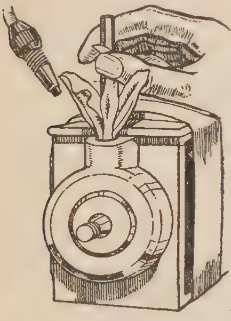


FIG. 242.—Cleaning the Slip Ring with a petrol-soaked rag wound round a pencil.

Stuck Rocker.—Should a rocker arm be sticking open (it cannot stick closed, for the arm opens the points forcibly), it should be detached and the bearing should be cleaned.

The Gap of the Contact Points.—The next thing to receive attention is the gap at the points. This should measure approximately half a millimetre when the points are fully open, and most magneto spanners are provided with a gauge so that this opening may be checked. As a matter of fact, the gap may vary considerably either way without a complete stoppage occurring, although difficult starting or misfiring at speed may result. Extreme wear on the points will only make the gap greater. What sometimes happens, however, is that the adjustable contact point becomes loose and works up the thread until there is very little or no gap, when the points are supposed to be open. This actually takes place, of course, whilst the magneto is running and subject to vibration, and, whilst running, it will continue to run unless there is no gap at all. Starting when the engine is cold, however, will be almost impossible.

Detaching the Contact Breaker.—This matter should receive attention, but should the engine still refuse to fire, the contact breaker should be detached. To do this, unscrew the primary pin, and lever the contact breaker off with a small screwdriver, or the stout blade of a penknife. All that can be done now is to make sure that there is no short circuit whatever.

Short Circuits.—The block is completely insulated from the main body of the contact breaker, except when the points are closed. If it is in any way "shorted" to the body, the circuit cannot be broken when the points open. There, no spark will occur, or, if it is a partial short, will not occur under compression.

A known but unusual form of trouble here is a tiny hair of metal, forced out of the thread by which the point is adjusted, actually touching the body of the contact breaker. Mischievous friends have been known to insert a minute portion of a strand of Bowden cable to serve the same purpose. It is, at any rate, worth examining the contact breaker very carefully and making sure that none of the small insulating washers are cracked or otherwise defective. Scrupulous cleanliness of all these little parts is essential, and if the platinum (or tungsten) points themselves are at all dirty or pitted, they should be cleaned and smoothed with a Swiss file. The surface of the magneto behind the contact breaker should also be carefully cleaned.

The Distributor.—Next remove the distributor and well clean the track and inside with a stiff brush, dipped in petrol, to remove metal or carbon dust. This dust will often cause arc-ing and hence misfiring; sometimes it causes a complete breakdown of the ignition system. This "tracking" is generally in evidence with distributors of the carbon brush type. With jump-gap distributors, if the segments are badly pitted, there is no remedy but to replace it, if misfiring is present and the rest of the system is in order. This is only necessary in cases of deep pitting of the segments. Another carbon brush distributor trouble is that the carbon brush may not be working freely in its holder, or it may be worn down. In the jump-spark type, the central or rotating electrode may be worn.

The Slip Ring.—The slip ring of the magneto should be cleaned with a petrol-soaked rag, pressing this into contact with a pencil and rotating the engine with the starting-handle; the ignition should be switched off during this operation (Fig. 242).

The most frequent cause of trouble is a stuck carbon brush. Remember there are *three* in most magnetos.

Coil Ignition—This system is practically trouble free, the usual trouble being a run-down battery. In such a case another battery should be connected *in parallel* (positive to positive and negative to negative), with the battery fitted to the car, and a start obtained by hand swinging.

Should the ignition fail even though the battery be fully charged, check over the H.T. cables and plugs first. Next check the make-and-break gap, inspect the electrodes in the distributor, then the coil, which may have water or moisture on its surface, or the coil base may not be earthed. The trouble can sometimes occur in the ignition switch, and generally to a loose connection, worn or stuck distributor brush or contact breaker rocker.

Plug and Contact Breaker Gaps.—The gap at the contact breaker should be, for coil ignition, ·025 inch; plug points ·020 inch; and for magneto ignition both should be ·020 inch. Too large a gap at the plug points will cause misfiring at slow speeds, and too small a gap will cause oiling-up. A small gap gives the effect of a slight advance in the ignition, and a large gap a slight retard (*see* Figs. 239 and 240).

When something happens, the magneto is blamed for having worked itself to death without a single wail. Hundreds of thousands of revolutions it has perhaps performed, giving faithful service.

On reading this section do not rush and immediately take it adrift. If you do, some of the magnetism will perhaps be lost and its performance impaired, however careful you may be. This is one of the reasons why reliable repairers magnetise *after* assembly. Under any circumstance, a keeper, in the form of a short length of iron, should be placed across the poles of the magnet *before* the armature is removed, and not after.

If the reader wishes to give his magneto an overhaul so that confidence is restored, he should carefully remove it from the engine, first turning the engine round until No. 1 cylinder is at firing point. Remove all the plugs so that the engine turns easily without having to overcome compression. Proof of No. 1 being at firing point is that both the valves on that cylinder will be closed, but the inlet valve just opening on No. 4, or the exhaust valve closing on that cylinder. A degree or two on the flywheel will not matter. Remove the high-tension distributor cover and bear in mind the position of the H.T. rotor as it should be pointing to the section on the cover that is attached to the wire going to No. 1 plug. Examine the interior of the cover and see if it is clean and smooth. It may be rough through " tracking," if so it should be turned and polished in the lathe. Some magnetos are of the " spark-jump " type, and with these the electrodes should not be too much burned or the point of the rotor too much wasted, otherwise the excessive gap will be an extra strain above that intended by the makers. If the H.T. cap is cleaned and then shows no signs of weakness, it can be left on the wires after being hitched up out of the way.

Before the set-screws or strap which secures the magneto to the platform are undone the coupling itself should be marked. The mark should be one that cannot be rubbed off, also it should be a very fine line and easily distinguished from any other lines that may have previously been made. To the uninitiated it is not such an easy matter to re-time a magneto, therefore one should be sure of this line in every way. It will save a lot of trouble, as also a notice on the radiator not to turn the engine. When the magneto is driven by an arm-shaped coupling the matter is easy, but the vernier coupling will have to have a mark right across both the metal parts and the rubber vernier that is between. To the mechanic it is all so simply replaced, but to the average owner it is where his trouble begins. If he is not sure he has replaced the magneto in the same position as before removed and there is a hitch in engine performance he is not sure if the trouble is inside the magneto or due to the refitted position. The moment the coupling is released the magneto will turn round and the mark move with it, therefore if you have not been sure of your ground, it is too late and the work should proceed.

It is not expected the reader will have a coupling-drawer, therefore other means must be adopted to remove this portion from its taper-shaft. Take off the castellated nut and see if a key has been fitted, otherwise it is improbable that the coupling can be replaced in its original position. However, as a key is nearly always fitted, the nut can be reversed and placed on the shaft again, but without the washer. The plain side of the nut should be level with the end of the shaft leaving a space between the nut and the coupling. Bunch a heap of rag on the table, or bench, and hold the magneto by the coupling immediately over the rag but not touching it. Strike the nut a fairly heavy but clean blow with, if possible, a copper hammer. A delicate tap is no use, there must be a good, square blow. If you do not know the way to use a hammer do not attempt it as you will bend the shaft, but get a friend who does. A good blow not only loosens the coupling but the nut and thread are not damaged by the many blows of the timid operator. The magneto will not come away from the coupling, and the rag is in case the coupling slips out of the hand.

Remove the contact-breaker cover and the contact-breaker timing ring, then the contact-breaker itself. Feel the armature spindle both ends for both up-and-down and end play. The only way this play can be taken up is to remove the outer races, first removing the spindle. Without the proper tools this is impossible, therefore will not be dealt with, and the same applies to the removal of the slip ring.

Should it be necessary to remove the armature for examination the earthing-brush and perhaps the safety spark gap-screw (as in some M.L. magnetos) should be taken out first, otherwise the slip ring may be damaged beyond further use. Removal of an end-plate will enable the armature to be withdrawn, using the aforesaid important keeper. Trouble itself in the armature is not by any means always superficial, but if it is it will be readily seen by the eye, and if not, the electrical test described is most likely to show it up; sometimes around the entrance to the slip ring, sometimes a bad connection to the condenser, and sometimes in the condenser itself. The test herewith is one without costly apparatus, therefore not final, but it is a good test nevertheless. Lightly wind a piece of copper wire around the slip ring, securing with pliers. Let one end be bent so that it reaches the body of the armature excepting a space of 9 mm. Lay the armature on a metal plate if you like, but not on an iron one. Lightly, and with the fingers only, insert the contact-breaker screw. Twist a wire around the end of the screw and connect to one pole of a four-volt battery. To the other pole of the battery fasten a wire and stroke the end across the teeth of the armature gear-wheel. If the armature is in order there will be a stream of sparks jumping across the 9 mm. gap. The quality of the spark will denote the condition of the armature. The spark should be "fat" and even jump a longer distance, but do not strain the "core," as it is called, by trying this out too much. If thin, it may be condenser trouble. If there is no spark at all there is a complete breakdown or a disconnection somewhere. Only specialists can remedy the fault, whatever it is. Condenser trouble is often located by blackened and rapidly burned points.

If the slip ring is pitted or stepped a good amateur mechanic can turn it up in the lathe, polishing with a fine piece of glasspaper. It must be remembered that deep cuts cannot be taken, nor will the construction permit too much material being removed.

Naturally, the reader will have examined the pick-up when the dust-cover was removed to see if there are any cracks or the brush worn.

The contact-breaker should be given an insulation test, especially in the central bushing. The long screw that secures the breaker-plate also electrically connects the contact-breaker screw to the armature winding, thereby serving two purposes, and this should be borne in mind. The insulation under the block carrying the screw rarely gives trouble, but the centre bush, owing to the pressure at times exerted by the screw, often splits, therefore should be examined with a magnifying-glass for cracks. At times this fault is not apparent until the pressure of the screw is exerted, therefore special precaution should be taken.

If the magneto is fitted with platinum points, tungsten cannot be substituted, as the magneto is not electrically designed for them. New points should be purchased from a reliable source, there being many imitations of this metal. The actual points supplied from the makers' stock should be preferably obtained, either from a good garage or the makers themselves. The reliable depot is ever-ready to obtain supplies from the right place for all motorists. Poor quality or incorrect points means trouble and expense.

See that the key which is formed on the boss at the back of the plate has not been improperly pressed home again. If so, lightly tap out again with the edge of the screw-driver. Too hard a blow will break it off. The opening should be accurately set according to the makers' advice, generally about ·020 inch. On a four-cylinder engine running at 3,000 revolutions per minute the speed of the moving point is several ft. per min. Every thousandth of an inch means several inches of travel for the point. A weak or partly corroded breaker spring may not be able to put up with the strain and is likely to give out at a most inconvenient moment. The moving-arm should be cleaned and the bushing cleaned also, but not lubricated. Any oil on this bush will cause trouble ; it is, therefore, designed to run dry. It is unwise to try to improve on the makers' advice in this respect. The fumes of both petrol and oil have a very deleterious effect on platinum.

The earthing-brush, generally situated in the under-body of the main casting, should be cleaned and replaced after assembly of the magneto proper. This brush is likely to get gummed up with long service and causes many mysterious troubles, such as not being able to switch off. Many a switch and wiring has been taken down, only to find this to be the trouble, especially in magnetos where the ball-races are insulated from the body of the magneto. This wood-fibre packing for the races serves two purposes. It assists in silent running and stops the H.T. current finding a path through the balls which ends in pitted races. The earth-brush has a definite purpose so should have proper attention.

Badly adjusted races mean badly meshed teeth in the half-time wheels, sometimes ending in the destruction of the teeth altogether. The pitch of the teeth being very fine does not allow for much error, therefore pay special attention here, as also the bush of the half-time wheel itself. It is impossible for the reader to attend to this himself but it should be noticed.

As already recommended, in assembly use sparingly some high melting point grease on the ball-races. Too much will lead to trouble and is not necessary for prolonged running as theoretically it does not " fade away " in any respect whatever.

It may be found that the heel of the rocker-arm is worn so much that the new points fitted will not " face up " squarely. It will be noticed the worn heel is fastened in its slot by two small pins. It is best to cut down the centre of the worn heel, afterwards pulling out the pins, which will now be loose. Do not let the hack-saw cut into the metal of the arm. A new heel can be bought from any service station for a few pence, therefore it is unwise to use some material that looks like the real thing, but is not. Ordinary cheap fibre will quickly wear away so do not waste time and money on an unsuitable material. When the heel has been fitted, do not cut off the unwanted portion until a trial has been made as, what should, or should not, be left is somewhat deceiving.

Before the pick-up is fitted try out the spark by holding the end of the screwdriver in the hole into which it fits, at the same time resting the blade against the metallic edge of the hole. Give the armature a sharp turn or two and watch if you get a spark. It is as well, especially for the novice, to check as each piece is re-assembled. Take nothing for granted and watch every step. When the pick-up has been fitted a test can be carried out to see if the spark will jump the safety gap provided. It should do so otherwise the work has been of little use, especially if the keeper has not been doing its work. Loss of magnetism may be the cause, therefore every time this excellent servant is taken adrift it should be re-magnetised before the final test.

If the magneto is provided with oilers only sewing machine oil should be used, and then not very frequently. The magneto, like all other reliable units of the modern car, functions best when left alone. A periodic inspection is quite enough, and it is the meddler who brings grist to the mill of the repairer.

MAGNETO SPANNER.—A small spanner expressly made for the purpose of adjusting the contact-points of magnetos.

MANGANESE BRONZE.—An alloy containing manganese, zinc, and copper. It is used at times for the production of close-grained and strong castings.

MANGANESE STEEL.—A steel of very high tensile strength containing 1¼ per cent. of carbon and about 12-15 per cent of manganese.

MANGANIN.—A resistance alloy containing 84 per cent. of copper, 4 per cent of nickel, and 12 per cent of manganese. Used in the making of high-grade resistance coils and rheostats.

MANIFOLD.—A term which generally denotes a short passage or chamber through which gases may flow, as for instance the exhaust manifold of a car engine, through which the spent gases flow from the exhaust ports of the cylinders.

MASSICOT.—See *Litharge.*

MECHANICAL EFFICIENCY.—The ratio of the brake horse-power of an engine to the actual horse-power obtained from it under running conditions.

The mechanical efficiency of an engine is governed by varying factors, including the speed at which it runs.

MECHANICAL EQUIVALENT OF HEAT.—A principle which holds that for a given amount of mechanical energy expended an equivalent amount of heat is obtained.

The principle is an important theoretical one in connection with automobile and engineering mechanics. It was first formerly developed by James Prescott Joule (1818-1889) in connection with his work on the Conservation of Energy.

MECHANICAL HORN.—Name given to a class of sound-producing devices which emit a warning note in consequence of a ratchet mechanism striking up against a metal diaphram, the rachet mechanism generally being operated by means of a plunger.

Warning devices of this type are often known generally as " Klaxon " horns.

MERCURY.—The only metal which is liquid at ordinary temperatures. It is heavy and possesses a silvery appearance. Owing to its property of breaking up into small and rapidly-moving globules when split over a surface, it has long received the name of " Quicksilver."

Mercury enters into the construction of thermometers and many types of scientific and electrical instruments.

MESH.—Term used to denote the engaging or interlocking of the teeth of adjacent gear wheels.

METHANE.—Chemical formula : CH_4. A light, colourless, inflammable gas, the well-known " Firedamp " of coal mines. Under normal running conditions only traces of this gas (about 0·009 per cent) occur in the exhaust gases of car engines, but in instances in which a car runs on an over-rich mixture, the methane content of its exhaust gases may be much higher.

METHYLATED SPIRIT.—Impure alcohol containing various substances purposely added, under Government regulations, to render it nauseous and unfit for drinking.

Among other uses, it is sometimes employed as an " anti-freeze " for the radiator water of a car, being added to the water in the proportion of about ¾ of a pint to a gallon of water.

METRE.—The fundamental unit of length in the Metric System of measurements. It equals 39·3707 inches.

Originally, the metre was evolved as representing the ten-millionth part of a quadrant of the Meridian, but more recent observations have shown that the standard metre is actually 0·0002 metre too short. Hence the metre is now only an arbitrary standard.

METRIC THREADS.—A series of Continental standard screw-threads, the only representative of which in this country's automobile engineering industry is the sparking-plug thread which follows this standard.

In the early days of motoring, ignition appliances were mainly imported from the Continent and, for this reason, the plugs were cut with threads of the prevailing Continental standard. The practice of providing such threads on sparking-plugs has prevailed to this day.

Metric standard threads are also known as " International Standard Threads." They were formulated in 1898 by an *International Congress for the Standardisation of Screw Threads*, which met at Zurich in that year. (See Tables at back.)

MICA.—A naturally-occurring insulating material of characteristic laminated structure. Being transparent, heat-resisting and having a high resistance, it is much used as a high-grade electrical insulator. For example, mica enters into the construction of many sparking-plugs.

MICANITE. — A manufactured form of mica consisting of small pieces of the mineral cemented together. Often used for electrical insulating purposes when large sheets of mica material are required. Sometimes for the inner insulation of transformers, magnetos, etc.

MICROMETER.—An instrument used for the purpose of effecting extremely fine measurements in the parts of an engine or machine. A good micrometer will measure accurately up to 1-10,000th of an inch.

MIL.—One-thousandth of an inch.

MILE.—The English unit of road measurement. One mile equals 1,760 yards, or 1·60 kilometres.

The name is an abbreviation of the Latin, *mille passuum*, a thousand paces.

MILEOMETER.—An instrument which measures in miles the total distance travelled by a car. It usually forms part of a speedometer.

MILLED NUT.—A nut possessing a circular edge which has been indented or milled.

MILLI.—A prefix which denotes a thousandth part. Thus a milliampere (milliamp.) is a thousandth part of an ampere, a milliammeter being an instrument which measures current in terms of milliamps.

MILLILITRE.—The thousandth part of a litre.

See *Cubic-centimetre*.

MILLING.—The process of indenting the edge of a small object such as a nut, with a series of fine lines in order to afford a firm grasp for the fingers during the manipulation of the object.

Terminals, screw-caps and other small articles of a like nature usually have their edges milled.

MINIUM.—See *Red lead.*

MIXTURE.—A term which in motoring language applies to the explosive mixture of air and fuel vapour which is drawn into the cylinder, and which is ignited therein.

A perfect mixture should contain sufficient air (but not more than sufficient) to combine with all the hydrogen and carbon contained in the fuel vapour. Such a mixture would give rise to perfect combustion. Unfortunately, this ideal is seldom realised under practical running conditions.

The reader will find that the broad principles of carburation are carefully explained under the heading *Carburettor.* As stated in that section the petrol level and the jet size play an important part in the correct functioning of the petrol engine. For further information also consult *Fuel Feed Systems.*

MOAN.—Term descriptive of the noise produced by a chain which is adjusted too tightly between two sprocket-wheels. Under these conditions, the "moan" tends to increase in pitch and intensity with increase in speed of the chain.

MOLECULE.—The smallest particle of a compound which can possess a separate existence and enter into chemical reactions. The combustion of fuel vapour and air within a petrol engine cylinder is a molecular process.

MOMENTUM.—A scientific term which expresses the amount of motion in a body. It is measured by multiplying together the mass of the moving body and its velocity.

MONKEY WRENCH.—A workshop term denoting a large adjustable spanner. It is often called a "Screw wrench." (See also *Spanners, Screwdrivers*, and *Pliers.*)

MOTORING LAW.—*Accident.*—Any motorist involved in an accident to any person or any horse or vehicle in charge of any person *must stop*, and, if required, must give his name and address and the name and address of the owner of the motor car. Failing this, the accident must be reported within 24 hours at a police station or to a police constable. Penalty for first offence: Not exceeding £10.

The Minister of Transport may direct an inquiry to be made into the cause of any accident involving a motor vehicle. A person authorised by the Minister may inspect a vehicle and at reasonable time enter premises where vehicle is situated. Obstruction of that person is an offence. The Report of an Inquiry shall not be used in legal proceedings instituted in consequence of the accident. Where a person is prosecuted for dangerous, reckless, or careless driving he shall not be convicted unless he was warned at the time the offence was committed or was served with a summons within 14 days of it.

Arrest.—A motorist is liable to arrest by any police constable in whose view he drives recklessly or dangerously or negligently if:

(1) He refuses to give his name and address, or

(2) Refuses to produce his licence on demand, or

(3) His car does not bear an identification mark.

Under a provision of the old Highways Act, any person may arrest a motorist who rides furiously on a highway to the danger of some person.

Aiding and Abetting.—Any person who aids, abets, counsels or procures the commission of any motoring offence is liable to be convicted in respect of that offence as if he were the principal offender. (Summary Jurisdiction Act, 1848.)

Appeal.—Very little time is given to any motorist desiring to appeal against a conviction for an offence, and prompt action is necessary.

An appeal can be made to Quarter Sessions against *any conviction* by a Court of Summary Jurisdiction.

Notice of Appeal has to be given within *seven days* to the Clerk of the Justices, and should also be given to the Chief Constable of Police. The notice can be sent by registered post, and must contain in general terms the grounds of the appeal.

Within *three days* after the notice has been given an appellant must enter into a recognisance to prosecute the appeal. The recognisance may be taken before any Court of Summary Jurisdiction.

An Appeal to Quarter Sessions results in the whole case being reheard from the beginning to end.

If a point of law alone is involved, the appeal may be to a Divisional Court and the convicting justices can be asked to "state a case." The seven-days time limit again applies. If a Court of Summary Jurisdiction acts in excess of its jurisdiction, an application can be made to the High Court for a writ of certiorari. An application for removal of suspension or disqualification may be made six months after date of conviction.

Audible Warning.—Every Motorist is bound, whenever it is reasonably necessary, to give audible warning of his approach, and he is also bound to carry on his machine some instrument capable of giving that warning. (Motor cars (Use and Construction) Order, 1904).

Automatic Traffic Signals.—It has been decided as the result of a test case, that these signals tell you *when* to stop, not where to stop.

The lines marked across the road at points where automatic traffic signals are used indicate the stopping line.

Bye-Laws.—Some Local Authorities have made bye-laws which affect all motorists and create offences for which they may be summoned. A bye-law is not enforceable if it is plainly unreasonable. When an offence is alleged against a bye-law a sealed copy of the bye-law in question must be produced in court or it must be proved by some other means.

Caravans (*See* Trailers).

Reckless, Dangerous and Careless Driving.—A person shall not drive without due care and attention or without reasonable consideration for other road users. A first or second conviction for this offence does not entail disqualification for holding or obtaining a licence.

If any person drives a car on a public highway *recklessly* or *negligently* or at a *speed* or in a *manner* which is *dangerous to the public having regard to all the circumstances of the case*, including the nature, condition and use of the highway, and to the amount of traffic which actually is at the time *or which might reasonably be expected to be on the highway*, he is guilty of an offence. Penalty for first offence: Not exceeding £50 or four months imprisonment; second offence: not exceeding £100 or four months imprisonment.

It is an offence to drive without due care or attention, or without reasonable consideration for other persons using the road. It is illegal to hold racing and speed trials on the highway. Any driver who drives or attempts to drive when under the influence of drink or a drug to such an extent as to be incapable of having proper control of the vehicle shall be liable to a fine not exceeding £50, or to imprisonment for a term not exceeding four months. On the second conviction to a fine not exceeding £100, and/or imprisonment.

Driving off the Highway.—Driving without lawful authority on to common land, moor land or any land not forming part of a road, or any bridle way, or foot way, except for a distance of 15 yards for the purpose of parking, is prohibited. If, however, a vehicle is driven off the highway for the purpose of saving life, extinguishing fire, or meeting a similar emergency, the driver shall not be convicted. This new legislation does not prejudice any local bye-laws, or affect the law of trespass, and confers no actual right to park a vehicle on any land. Penalties: First conviction, fine up to £5. Second and subsequent conviction, fine up to £10.

Driving Licence.

(1) *Cost.*—Five shillings.

(2) *Where Obtained.*—From County or Borough Council for district in which applicant resides. The driving licence must be signed by the owner.

(3) *Physical Fitness.*—On application for the grant of a driving licence the applicant shall make a declaration on the form as to whether or not he is suffering from any disease or physical disability as specified on it, or any other disease or physical disability which will be likely to cause him as a driver of a motor vehicle to be a source of danger to the public. The authorities will refuse to grant a licence if the applicant is suffering from such disabilities, and in such cases they will grant a limited licence to drive an invalid carriage if they are satisfied that the applicant is fit enough

to drive such a carriage. The applicant may, in certain cases on payment of a prescribed fee claim to be subjected to a test as to his fitness. The applicant may appeal to a Court of Summary Jurisdiction if a licence is refused him.

(4) *Duration.*—One year from date of issue unless holder disqualified.

(5) *Age of Applicant.* — Not under 17 years. If applicant satisfies the licensing authorities that he has driven for six months prior to January 1, 1931, a driving licence shall be issued to him.

(6) *Renewal.* — At any time within one month before date of expiration. The authorities may restrict the licence to the driving of a particular class of vehicle, and will issue a new licence to that effect.

(7) *Lost.*—Duplicate can be obtained from authority which issued original on payment of one shilling, and satisfying authority as to loss.

(8) *Endorsement.* — Any person convicted of an offence under the Road Traffic Act, 1930, or in connection with the driving of a motor car, *may* be ordered to produce his licence for endorsement with particulars of the offence.

Where there is no fresh endorsement for a period of three years, then the holder of an endorsed licence is entitled to have a " clean " licence issued to him.

(8) *Suspension.*—A licence may be suspended under similar circumstances to those justifying an endorsement. The suspension may be for any period at the discretion of convicting magistrates.

(9) *Disqualification.*—Is possible under circumstances justifying suspension. No fixed time limit. Twelve months' disqualification follows automatically a conviction for being drunk in charge of a motor cycle. (See also " Reckless, Dangerous and Careless Driving.")

(10) *When Necessary.*—When riding on a road to which the general public has access.

(11) *Production.*—A driving licence must be produced by any person driving an automobile when demand is made therefor by a police constable. The constable may *not* handle the licence. If unable immediately to produce the licence, driver cannot be convicted of an offence if, within 5 days of the request for production, he produces the licence in person at any Police Station he may specify.

Lights.—Between half an hour after sunset and half an hour before sunrise a white light must be displayed in front and a red light to the rear. The number plates must be fully illuminated so that the registration numbers can easily be read. During Summer Time the above period is extended to one hour.

Number Plates.—(1) Each plate must have the letters and figures in line or the letters above the figures. The plate must be flat, but need not be rectangular.

(2) The ground of the plate must be black, and the letters and the figures of an indelible white or raised from the plate.

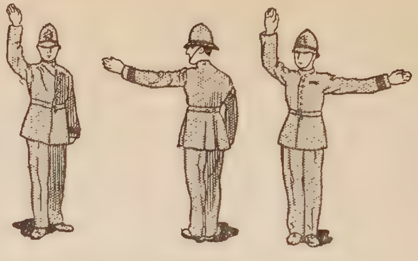
(3) All letters and figures of front number plates must be 3½ in. high and ⅝ in. broad. The total width of the space taken by every letter and figure (except the figure 1) must be 2½ in.

(4) The space between adjoining letters and figures must be ½ in., and a similar margin must exist between any letters or figures and the edge of the plate. (Registration and Licencing Regulations.)

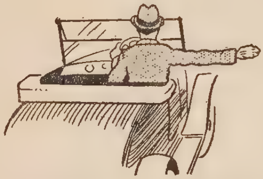
(5) If the plate is not properly fixed or is in any way obscured or

Fig. 243.

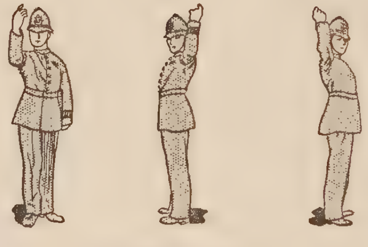
TRAFFIC SIGNALS AND WHAT THEY MEAN



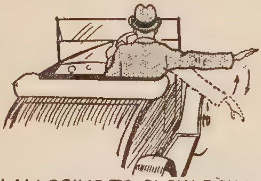
"STOP"



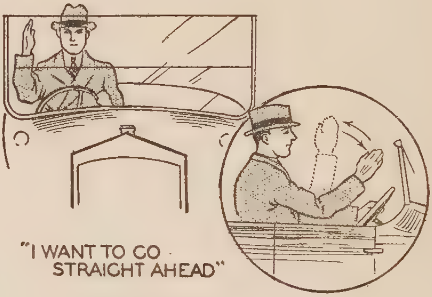
"I AM GOING TO TURN RIGHT"



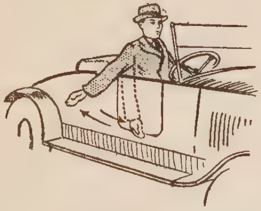
"PROCEED"



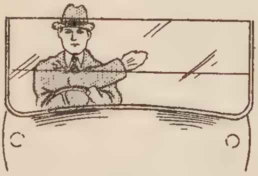
"I AM GOING TO SLOW DOWN, STOP OR TURN LEFT"



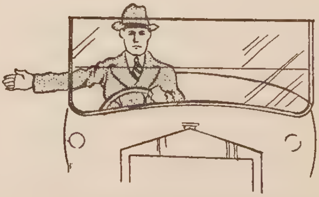
"I WANT TO GO STRAIGHT AHEAD"



"YOU MAY PASS ME ON MY RIGHT"



"I WANT TO TURN LEFT"



"I WANT TO TURN RIGHT"

allowed to become not easily distinguishable, a person driving is guilty of an offence, *unless* he can show that he took all steps reasonably practicable to prevent the plate being obscured, etc.

Rear number plates must conform to the dimensions stated on page 211.

Penalties.—When a motorist is fined by the Justices a warrant committing him to prison for non-payment shall not be issued forthwith unless:

1. The Court is satisfied he can pay immediately, or
2. He does not ask for time to pay after being asked by the Court as to whether he requires time, or
3. He fails to satisfy the Court that he has a fixed abode within its jurisdiction, or
4. There is some special reason for immediate payment being insisted on.

When any person desires time for payment the Court must hear any reason he advances, and if time is granted it must not be for less than seven days.

Registration Book.—A registration book is issued to every owner of a car who applies for an excise licence. When a car is sold the seller should hand over the book to the buyer and notify the County Authority as to the sale, giving name and address of buyer. The buyer must write his name and address in the book and send it to the County Authority which last registered the car.

The book must be produced to a police or registration officer on reasonable notice being given. (It is not necessary to carry the book about.)

No alteration must be made to any figure or letter in the book.

A duplicate book can be obtained from the issuing authority for five shillings if the original is lost. Any change of address must be notified to the County Authority.

Speed Limit.—If the vehicle is adapted to carry not more than seven passengers, exclusive of the driver, all its wheels being fitted with pneumatic tyres, and no trailer is drawn, it is not subject to any general speed limit. Invalid carriages are excepted.

If the vehicle is adapted to carry more than seven passengers, exclusive of the driver, the maximum speed shall be thirty miles per hour.

Motor car with trailer, and invalid carriages: maximum speed twenty miles per hour.

Local speed limits of 10 m.p.h. or under have largely been abolished although some still hold.

Road Fund Licences.—Applications should be addressed to offices of the County Council, and must be accompanied by Form R.F. 1a (or the appropriate form in the case of re-declarations) and the necessary remittance for duty. A licence cannot be renewed on a letter of request only.

When a change of ownership has occurred since the vehicle was last licensed, the new owner must re-declare on the form of declaration appropriate to the class of vehicle.

This may be obtained by post from the Council, or by personal application at any Money Order post office in Great Britain.

Fill up the form R.F. 1a, for renewal of licences when no change has taken place, and for re-declarations, R.F. 1-2.

When, however, a second-hand vehicle is purchased the procedure is a little different and the following are the respective duties of the vendor and purchaser.

The vendor should hand the registration book to the purchaser and at the same time write to the registration authority setting out (*a*) the index mark and number of the automobile, and, (*b*) the make and class of the automobile, and (*c*) the name and address of the person to whom the vehicle has been sold. A post office form for this purpose is obtainable.

The purchaser should see that he receives the registration book (incidentally he should check the particulars in the registration book with the car he has purchased to make quite sure that the car is the one referred to in the registration book) and he should then send the registration book to the authority with whom the machine is registered, having first filled up the first vacant space under the heading " Change " with his full name and address and signature. The registration will then be transferred to his name and the book returned to him.

If by any chance the registration book has been mislaid or lost, then the licensing authority, upon payment of a fee of 5*s*., will issue a fresh registration book.

If the licence itself has been lost or has become illegible through rain or sun then it must be immediately returned to be replaced. To drive a car with an illegible licence is an offence for which the owner and/or driver can be convicted and fined. A duplicate can be obtained from the registration authority, but the fee of 5*s*. will again be demanded unless it is possible to satisfy the authority that the illegibility or fading is not due to any neglect or carelessness.

Traffic Directions. — When a police constable in uniform is regulating traffic *in a street*, any person driving a car who wilfully neglects or refuses to stop his car or make it proceed or keep to a particular line of traffic when directed to do so by the police constable in the execution of his duty becomes liable to a fine not exceeding £5.

N.B.—This provision is frequently made use of by the police when any signal given by them when on point duty is ignored.

The Highway Code.—The Highway Code has been issued by the Minister of Transport with the authority of Parliament under Section 45 of the Road Traffic Act, 1930. Copies of a booklet giving the Code in full are obtainable for 1*d*. from His Majesty's Stationary Office, Kingsway, W.C.2. The chief provisions are as follows. It is important to note that whilst failure to observe provisions of the Highway Code is not an offence, for the code has not the power of an Act of Parliament, there can be no question that such a breach would be taken into account in legal procedures. The adoption of this code will undoubtedly add to the safety of the highways and motoring generally. The code is intended as a supplementary guide to the proper use of the highway, and as a code of good manners to be observed by all courteous and considerate persons. Under the acts and regulations governing the use of the highways certain actions are definitely forbidden as being offensive.

Summary of the Highway Code.—All persons have a right to use the roadway and an obligation to respect the rights of others. Keep on guard against the errors of others ; never take a risk in the hope or expectation that every one else will do what is necessary to avoid the consequences of your rashness. Take special care in bad weather as when the roads are slippery all road users have less control over their movements. Pedestrians should always walk on the footpath where one is provided; if there is no footpath it is generally better to walk on the right of the road so as to face oncoming traffic. When you intend to stop, slow down or change direction, give the appropriate signal clearly, definitely, and in good time. Never overtake unless you can see sufficiently far ahead to do so with safety. Do not overtake at cross-roads. Do not cut in. When being overtaken by another driver try to help and not to hinder. Do not accelerate at such a moment. No vehicle has a right of way at cross-roads, but it is the duty of a driver on a minor road when approaching a major road to go very slowly and to give way to traffic on it. Carefully follow the indications given by the white lines. Do not leave your vehicle at a standstill in such a position as to cause an inconvenience to residents or other users of the road. Do not leave your machine standing in the highway with the headlights on. Switch on to dim. Do not leave your machine facing the wrong way at night. During the daytime in foggy weather use your lights, switching on to dim. Horns should not be used unnecessarily and should not be used to show annoyance and impatience. Respect the rights of pedestrians. Aged or infirmed people and young children and those in charge of them call for your especial courtesy. If the roads are wet or muddy try to avoid splashing; slow down or stop when requested to do so by those in charge of horses or other animals. Remember that, as a motorist, exactly the same rules apply to you as all other drivers. Make no attempt to gain a forward position in a traffic block by means of the narrow spaces between stationary vehicles. They may start suddenly and you will impede them and endanger yourself. Sudden noisy acceleration is disturbing and unnecessary. Pedal cyclists are instructed not to ride more than two abreast, and to get into single file when other traffic wishes to pass. They are also asked to not wobble about the road, nor to hang on to a motor vehicle for the purpose of being towed. They may not hold on to a motor vehicle even when it is stationary in a traffic hold-up. Note the provisions of the new Road Traffic Act (1934).

Insurance (*Compulsory Third Party*).—A person may not use or permit any other person to use a motor vehicle on the road unless such use is covered by insurance against third-party claims. This does not require the owner to cover a person in his employ against death or bodily injury arising out of and in the course of his employment—a liability which is covered by other statutes.

Where compensation is paid under the provisions of compulsory insurance, and where to the knowledge of the insurer a third party has received hospital treatment, the insurer shall also pay to the hospital a sum not exceeding £25 for each person so treated. This obligation does not apply where a charge has already been made by the hospital.

In addition to the usual policy, or cover note, the insurance company shall hand to the owner a "certificate of insurance" in the prescribed form and when applying for his car licence, the applicant must—by production of the insurance certificate or otherwise—satisfy the Licensing Authority that the necessary cover against third-party risks will be in force at the time the licence becomes operative.

The driver of a motor vehicle shall, when requested by a police constable, give his name and address, also the name and address of the owner of the vehicle, and produce the insurance certificate. If he cannot produce it immediately, he must produce it in person within 5 days at any Police Station he may specify.

Trailers (*Caravans*). — Separate registration not necessary. Tax, £1 extra if drawn by solo motor cycle. Every trailer must have an efficient braking system.

Regulation number plate must be displayed at rear, and lit at night.

In towing, the tow-rope must not exceed 15 ft. in length, and the rope or chain must be easily distinguishable by other users of the road. Mark " On Tow."

MOTOR SHAFT.—An old term denoting the crankshaft. Now seldom used.

MUFFLER.—An American term for the silencer. Seldom used nowadays.

MULTIPLE-DISC CLUTCH.—A form of clutch (of which there are many varieties) comprising a number of phosphor-bronze and steel discs assembled alternately. The steel discs revolve, usually, with the clutch-shaft, the phosphor-bronze discs rotating with the flywheel shaft. By compressing these discs together the power is transmitted from the engine to the clutch-shaft. Clutches of this type, having no rough frictional surfaces, operate in an oil-bath. (See *Clutches*.)

MUSHROOM VALVE. — Name sometimes given to an engine valve in consequence of the resemblance of its upper portion to a mushroom.

N

NAPHTHA. — A heavy liquid obtained from coal-tar. Used as a fuel for certain types of internal-combustion engines on heavy road vehicles. It contains largely the three xylenes, together with small amounts of other hydrocarbon liquids.

See —*Xylene*.

NAPHTHALENE.—Chemical formula : $C_1{}^{\circ}H_8$. A well-known white crystalline hydrocarbon material having a peculiar and characteristic smell. Melting-point, 79°C. It is produced from coal-tar and has many uses as a disinfectant, etc.

On account of its high carbon content, it is sometimes used as a fuel " dope," being dissolved in the fuel for the supposed purpose of giving more power to it, or for deriving a better economy with its use. Naphthalene usually forms the basis of all proprietary petrol dopes, its smell, in many instances, being skilfully disguised.

NEAR-SIDE.—The left-hand side of a car when sitting with one's face to the engine.

In this country it is the side of the car nearest to the pavement when the car is being driven in the normal manner.

NEEDLE VALVE.—The form of fuel-supply valve generally employed in a carburettor. It comprises a finely-pointed steel rod, which, under the influence of the carburettor float, rises and falls within a metal seating, thus controlling the flow of liquid fuel in the float chamber of the carburettor.

NEGATIVE ACCELERATION.—See *Acceleration*.

NEGATIVE POLE.—Applied to a battery or accumulator, this is the terminal or electrode *towards* which the current flows along a circuit connected to the cell. It is denoted by the sign —.

NEON.—A colourless, odourless gas existing in the atmosphere in small traces, 1,000 parts of air (by volume) containing approximately 0·015 parts of neon. It finds an increasing commercial use in the construction of neon lamps and signs, which contain neon gas at low pressure within them and which glow with a characteristic orange light when a high-tension potential is applied to them. Neon tubes of this description are now fitted to many cars for the purpose of serving as direction indicators, etc., and many lighting bulbs are neon-filled.

From the Greek, *Neos*, new.

NICHROME.—A nickel-chromium alloy used in the making of resistance wires for shunts and instrument coils. It has a high ohmic resistance value.

NICKEL.—A silvery metal possessing many uses in the automobile industry. Its chemical solutions are largely used for nickel-plating. Nickel alloys with many metals, ferrous and non-ferrous, imparting very special properties, such as hardness, to them. Pure nickel, on account of its heat-resistive powers, is often employed for the making of sparking-plug electrodes.

See *Nickel-steel*, *Nickel-silver*.

NICKEL-CHROME STEEL.—Name given to a recently-developed class of steels containing nickel and chromium. Generally, the minimum percentages of nickel and chromium in these steels are 5 and 10 respectively. Such steels may also contain varying small amounts of other substances such as manganese, tungsten, vanadium, molybdenum, etc.

When softened, nickel-chrome steels can be pressed readily. They are increasingly used for the construction of car frames. Their tensile strengths are high, and they are almost entirely free from atmospheric rusting, oxidisation, or deterioration.

Steels of this type are often termed "Austenitic" steels, after W. C. Roberts-Austen, a famous steel-worker.

NICKEL SILVER.—Name given to a class of resistance alloys used for making electrical resistance coils and elements. The name is synonymous with German silver.

The composition of nickel silver varies, its electrical resistance being mainly governed by the nickel content of the alloy.

An average quality nickel silver contains approximately the following: copper 50 per cent, zinc 25 per cent, nickel 25 per cent. A little lead is often added to the alloy in order to render it more malleable and ductile.

NICKEL-STEEL.—Name given to a class of steels containing varying amounts of nickel. Nickel-steels are hard and tough. They will stand up to continuous shocks well. Hence their extensive use in the making of car frames and other parts. The various chrome-nickel steels are a modern development of them.

NIPPLE.—Name given to a small metal projection containing an orifice communicating with a bearing surface and through which oil or grease may be injected by means of a grease gun.

NITROGEN.—One of the gaseous constituents of the atmosphere forming about four-fifths of the total volume of the atmosphere. It acts in all combustion processes as a dilutent of the oxygen and passes through the internal-combustion engine unchanged.

See *Air*.

NOISES: CAUSE AND CURE.—It can be taken as a truism that no car, however well-built and expensive it may be is ever (during its life) entirely free from annoying and elusive little squeaks and rattles, which have nothing whatever to do with the inherent and ineradicable noise produced by the machinery itself. Every private owner, unless he is what might be described as "car callous," spends a considerable period of time in searching for the causes of, and seeking a remedy for, the aggravating noises which can do so much to detract from the pleasure of motoring. It is surprising how baffling some of these squeaks can be. Often enough it is difficult to tell from what part of the car they arise. In some circumstances a juddering noise may sound as though it is coming from the front of the car, and the driver becomes convinced that the trouble lies under the bonnet. Later in the day, maybe, he is not quite so sure, and by the time the run is finished he is almost equally certain that he can find its source under the back seats!

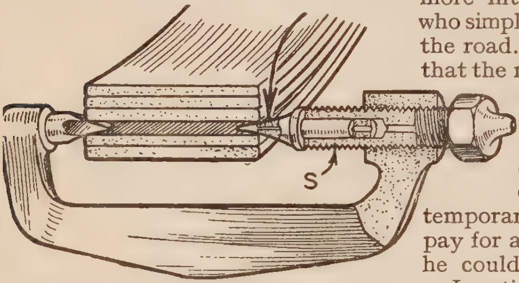


FIG. 244.—Noisy Leaf Springs can effectively be silenced by the periodic greasing with this efficient tool.

Some motorists, driven to desperation after repeated ineffectual attempts to trace these troubles, take their cars into a garage leaving instructions for the workmen to "get on with the job." This is really a mistaken policy for, as a general rule, garage people are no better at tracing squeaks than the owner himself; in fact the latter has a better chance for he must essentially know his car far more intimately than a service man who simply gives it a run up and down the road. It may happen of course, that the mechanic is lucky and spots the trouble at once; on the other hand it more often happens that a few drops of oil squirted here and there cured some of the noise temporarily, and the owner has to pay for a man's time on a job which he could well have done himself.

Locating the Cause.—Rattles and other noises which are known to be caused by certain components or fittings in the car are naturally more easily remedied than those which prove elusive. A cure of some sort can usually be devised at once for loose windows, bad bonnet fittings, and so forth. The chief difficulty the owner-driver has to face is in locating the primary cause. One of the best ways of setting about the job of tracking down a persistent

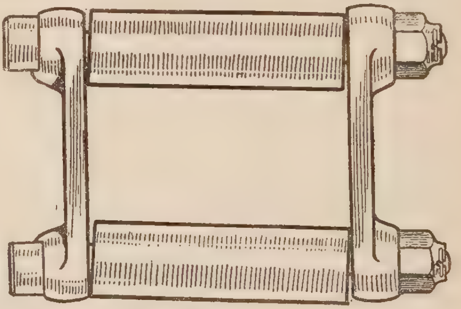


FIG. 245.—Worn Shackles give rise to a peculiar "clicking" noise.

squeak or rattle is to take the car to the top of a long hill and allow it to free-wheel down with the engine switched off. Without mechanical noises it is much easier to listen attentively, and in this way it is usually possible to ascertain roughly in what part of the car the trouble lies. Having done this bring the car to rest and, standing on each of the running-boards in turn and holding to a door-pillar, hood-stick, or some other convenient hand-hold, rock the car up and down vigorously. This will set up stresses in the body and chassis, and to some extent amplify those that are caused when the car is under way, thereby magnifying the noises so they can be more easily heard and detected.

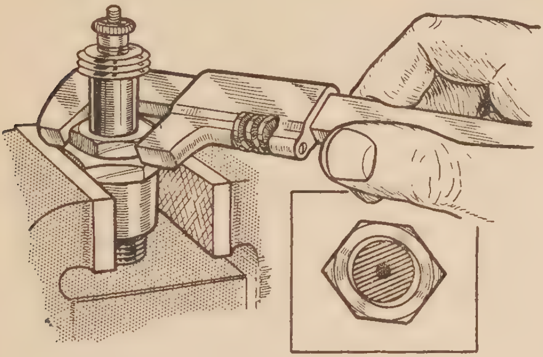


FIG. 246.—A loose Plug Centre will sometimes give rise to a peculiar hissing noise.

The Most Common Causes.—Taking the car from radiator to rear-axle, we will outline some of the most usual causes of squeaks and suggest some cures for them. Bonnets are very prone to produce these noises, and it will often be found that the straps of fabric, interposed between the radiator and the scuttle and the bonnet-lid, are dry and shiny in certain places where the lid has been pressing and rubbing against them. These are very often the causes of squeaks, and the cure is obvious. A few drops of light oil or paraffin on the shiny part will work wonders. Sometimes the bonnets do not fit sufficiently tight; then it will pay to fit stronger retaining clips or to alter the positions of the existing ones. Some bonnet fasteners embody little rubber studs or buffers; these perish in time and should be renewed.

In some cases squeaks arise from the points where the mudguard skirts are attached to the frame members. The fabric packing interposed should be inspected and, if necessary, renewed whilst tightening up the mudguard bolts—those actually securing the skirts to the frame, and also the supporting struts.

With the bonnet open, run over the control rods and examine

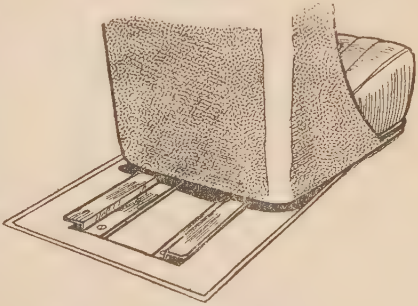


FIG. 247.—Sliding seat rails, if a bad fit, will cause rattle.

particularly the points where they penetrate the dash. Judicious use of the oil-can may again help—and do not forget that some rattles which have proved elusive for a considerable period can often be traced to loose tools in the boxes which are nowadays so frequently fitted under the bonnet.

Windscreens and windows have a tendency to contribute towards these minor annoying noises. Make sure that the clips and brackets which hold an opening screen in position are really effective, and that the screen when closed fits snugly against the pillars. Windows themselves, whether of the wind-up or sliding type, often rattle in the doorframes. One way of stopping this is to replace the fabric in the guides in which the windows slide. A simpler and less expensive way is to employ little rubber window-wedges. These can be obtained from most garages and from ironmongers and hardware stores. There are also on the market rattle-stoppers, specially designed for this purpose. They are made to clip to the glass and, by turning a knurled nut, a rubber buffer is made to press against the pane, so holding it securely. Wind-up windows, which squeak when raised and lowered, often present a problem. It is not wise to oil the guides; a better plan is to rub a thick carpenter's pencil up and down the grooves. The "lead" of the pencil forms an excellent lubricant and the glass does not get dirty through oil spreading and collecting dust.

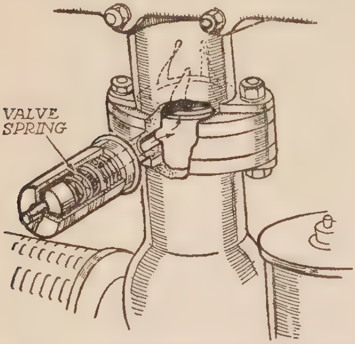


FIG. 248.—The automatic extra-air valve—an excellent device. If fitted check this occasionally to ensure that the moving parts have not worn.

Examine the Floorboards.—Floorboards should always fit perfectly; unless they do they are bound to rattle, and, in addition, they admit draughts, moisture, and dust. It is a wise plan to take the floorboards out periodically and wipe away from the undersides all the mud and oil which collects on them and so makes for imperfect fitting. Use a screwdriver on the turn buckles, and if the packing is worn, replace it. Strips of rubber, cut from an old inner tube, can often be successfully pressed into service here.

It is a very difficult matter to silence a rattling door. A temporary cure may be made by fitting new rubber stoppers, but, especially with big and heavy doors, these are soon worn away and the noise returns. Re-positioning the lock-catches by packing them with washers will give them a better hold, especially if they are of the modern type with a pointed peg engaging with a hole in a lug.

Many a mysterious rattle has been traced eventually to brake-rods. In some cars these rods pass through guides attached to the frame. These are all points which should be inspected and, whilst working under the car, it is as well to give the silencing system an examination. The constant expansion and contraction of the exhaust system is very prone to loosen the nuts and bolts of clips, whilst it sometimes happens that a baffle becomes loose in the silencer, causing a noise which may very well defeat anyone who is not experienced, or has not heard about such a trouble previously.

A Few Other Troubles.—Shock-absorbers, too, may be at fault. Whether of the friction or hydraulic type it is quite possible that a turn or two of the nuts which secure the bushes on the frame and axles will put a stop to noise. At the same time, make sure that the "shockers" themselves, if of the friction type, are not free to vibrate against any part of the frame, a brake rod, exhaust-pipe, or mud-guard.

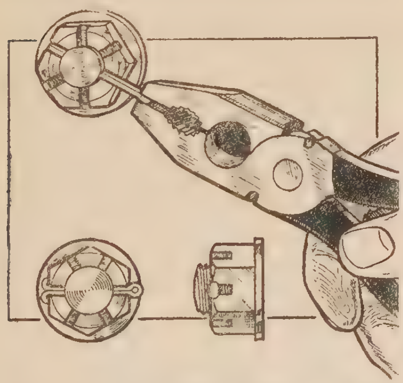


FIG. 249.—Parts which frequently vibrate loose should have castellated nuts, secured with split pins.

Luggage-grids, number-plates, and even speedometer and revolution-counter cables are frequent offenders, and they can all be cured, either with a spanner, a screwdriver, or a can of oil.

A preparation which has come on the market within the last two or three years—"penetrating oil"—is a very valuable assistant. It should not, however, be relied upon solely, for it obviously cannot effect a permanent cure as its efficiency depreciates in time.

NONANE. — Chemical formula: C_9H_{20}. A colourless hydrocarbon liquid. Boiling-point, 150°C. Specific gravity, 0·718. Is present in petrol.

NON-RETURN VALVE.—Name given to a class of gas or liquid-valves which permit only of the flow of gases or liquids through them in one direction.

O

OCTANE. — Chemical formula: C_8H_{18}. A colourless hydrocarbon liquid. Boiling point, 125° C. Specific gravity, 0·702. Occurs in petrol fuels.

OCTANE NUMBER.—Term used to assess the anti-knock value of petrol.

Iso-Octane, which is a constituent of petrol, possesses the highest anti-knock value of all petrol constituents. Hence, for comparative purposes, its anti-knock properties are taken as a unit of reference, and a petrol made up of 100 per cent. of Iso-Octane would have an anti-knock value of 100. A petrol having an anti-knock value of 65 would correspond in freedom from knocking to a fuel containing 65 per cent of Iso-Octane.

First quality petrol has, usually, an Octane number of between 65 and 70. "Anti-knock" petrols have an Octane number of between 75 and 80.

OHM.—The unit of electrical resistance. The standard ohm is the resistance of a column of mercury 106·3 cms. long, 1 sq. mm. in cross-section, and of a mass 14·4521 grammes at the temperature of melting ice.

After Dr. George Ohm, a German professor of mathematics, born in 1781.

OIL CONSUMPTION.—This section explains the causes of excessive oil consumption and shows how this trouble may be overcome. A common failing in cars which have more than about 25,000 miles to their credit is that of excessive oil consumption. There are a number of cars that have covered 50,000 miles without the consumption of oil increasing to any great extent, but these are the exception rather than the rule, and in nearly every case it can be proved that the cars have been run-in with more than usual care.

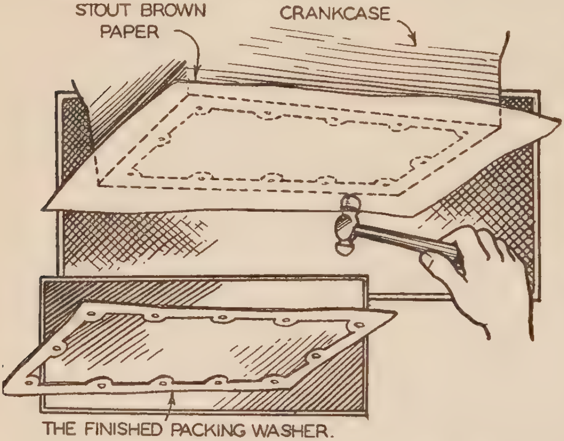


Fig. 250.—A new packing washer for the oil sump tray can be made from stout brown paper by rubbing this against the edges of the casting with a hammer or mallet.

The inexperienced motorist might well ask exactly what is meant by heavy oil consumption, as, after all, the expression is purely a comparative one. In the case of the average type of small touring or semi-sports machine of up to 12 h.p. a figure of 1,000 miles per gallon of oil can be considered as a fair average. If the car requires appreciably more oil than this for every 1,000 miles the consumption should be considered as excessive, provided that the car is not driven consistently at high speeds.

Sources of Leakage.—When it is found that too much oil is being used a careful examination of the engine should be made. In the first place look over the engine unit, in general give especial attention to the oil pump and sump to make sure that there is no leakage at these points. Also look for drips on the garage floor after the car has been standing overnight; the presence of these will point to a leak. If there are signs of leakage the bolts which hold the tray of the sump should be checked over and tightened if necessary. Start with those in the middle and gradually work toward the ends. In doing this it might be found that the tray has been bent, with a result that a good tight joint cannot be secured. The obvious remedy is to drain the sump, remove the tray and carefully straighten it. Another reason for the leakage might be that the fabric washer between the tray and the engine casting has been damaged due to bad fitting. The simplest method of dealing with this is to remove the tray and fit a new washer. Stout and softish brown paper is most suitable, and this can very easily be cut to the proper shape by holding it against the bottom of the casting and striking the edges with a mallet or a light hammer, as shown in Fig. 250. The holes for the studs can be cut out in the same way by using the ball end of the hammer, or by means of a small egg-ended mallet.

After the washer has been cut to shape it should be liberally coated with gold size, or similar material, and fitted into place before the size becomes dry.

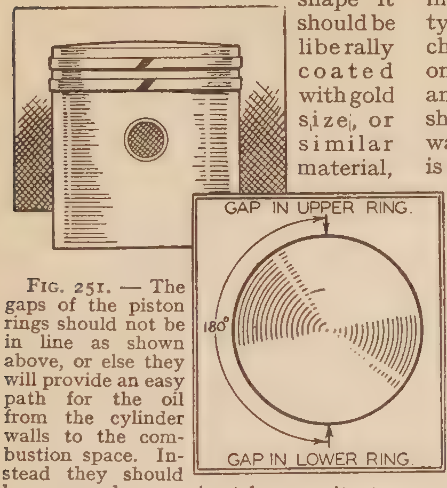


FIG. 251. — The gaps of the piston rings should not be in line as shown above, or else they will provide an easy path for the oil from the cylinder walls to the combustion space. Instead they should be arranged approximately opposite to each other as shown inset.

Another spot where oil leakage can occur on some engines is around the edges of the valve-cover in a side-valve type, or round the rocker-shaft cover in an overhead valve unit. A bent cover or damaged cork washer will be responsible in both cases and, therefore, the cure is obvious.

In some overhead valve engines, which have an overhead camshaft with a vertical drive through a forward-placed dynamo, oil leakage can take place past the oil-retaining washer if this has become damaged. In that case it will be found that the front part of the engine and the inside of the radiator are always oily. The fitting of a new washer will soon put matters right.

A Worn Rear Main Bearing.— In engines which have plain main crankshaft bearings it is not unusual to find that oil leaks past the rear one into the clutch housing. Assuming the clutch to be of the dry-plate type, such leakage can readily be checked by removing the drain plug on the base of the clutch housing and noting if any oil runs out; this should be done while the engine is warm. Should it be found that oil is leaking in this way it will become necessary to completely dismantle the engine and then to re-metal the bearing or devise some means of reducing the pressure upon it. Where makers have found that, in some of their older models, oil leakage does take place past the rear main bearing, they will no doubt have discovered a cure, and will, therefore, be pleased to advise any owner of their car who writes for advice. In doing so state the engine number of the particular car with which trouble is experienced.

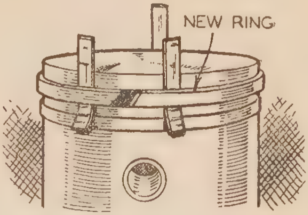
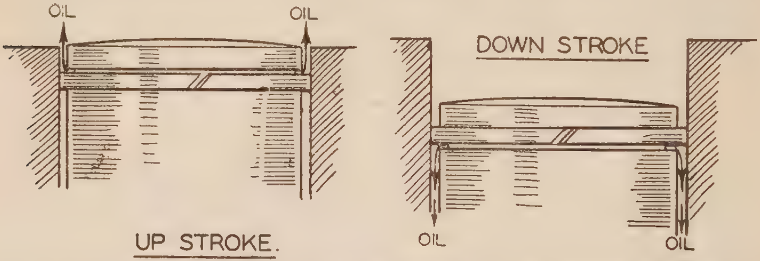


FIG. 252.—New piston rings can most easily be fitted by using three strips of thin metal as guides, as shown above.

When the Oil is being Burnt.— The points referred to above are purely superficial causes; there are others which are more serious. Most probably the oil is being burnt, due to its passing into the combustion chambers, and this will be quite obvious in many cases, due to the fact that the plugs frequently need to be changed and cleaned ; in fact, the trouble may be so pronounced that one cylinder will refuse to fire at all until the plug has been removed and the oil removed from its points. When the trouble is not quite so pronounced it will be evidenced by the fact that clouds of smoke are blown out of the exhaust pipe every time the engine is speeded up, after it has been idling or running downhill with closed throttle.

In either case, there is clearly too much oil passing into the cylinder heads. The reason can only be traced by removing the cylinder head and making closer inspection. It might then be found that the cylinders are badly worn and that the pistons are, therefore, more or less slack inside their bores. Accurate measurement with a micrometer is the only real test, but a good idea can be gained by trying to rock the pistons about. There will (and should be) a little permissible movement from side to side of the block, but there should scarcely be any in the opposite direction. If there is a re-bore will probably be called for, although the fitting of new piston rings of one of the special types now made for reducing oil consumption might do the trick.



Figs. 253 and 254.—If the piston rings are a loose fit in their grooves, oil will be driven up the cylinder walls and into the combustion space, as shown in the two diagrams above.

If in doubt it will pay to have the cylinders and pistons measured by a competent mechanic, and if the end-to-end wear exceeds 5 thous. per inch of cylinder bore, a rebore will be the only truly satisfactory remedy.

Examine the Piston Rings.—If the wear is not excessive the pistons should be removed and the rings examined. In the majority of cases this can be done by removing the sump and disconnecting the big ends, when the pistons can be removed, along with their connecting rods. With occasional (small) engines which have oil baffles fitted at the base of the bores, it is essential to lift the entire cylinder block, thereby gaining access to the big ends from the top. The block can be raised by hand, but care must be exercised to see that it is raised quite vertically and that the pistons are supported so that they do not swing over on to the crankcase, and thus become damaged.

After the pistons have been exposed examine the rings carefully. Should it be found that the gaps are practically in line, it is probable that this would be the cause of excessive oiling of one cylinder (*see* Fig. 251). Close up the rings, and if it is found that the ends will not meet, new rings should certainly be fitted.

First of all obtain some new ones of the correct size and type, and file down the ends (using a dead-smooth or Swiss file) until the rings will fit inside the cylinder bore (about half-way down), with a gap clearance of about 3 thous. clearance. They can then be fitted to the pistons, as shown in Fig. 252 by using three strips of thin steel or tin-plate as guides.

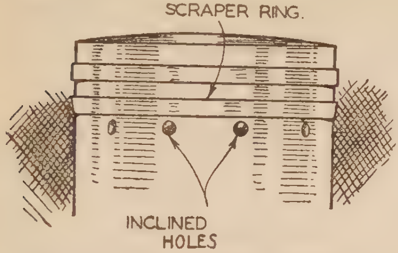


Fig. 255.—It is sometimes helpful, in the interests of reduced oil consumption, to make a series of inclined holes below the lower ring; these serve as oil-return ports. Too many holes should not be made or else the strength of the piston might seriously be reduced.

It should also be noticed if the rings are a good fit in their grooves, because if they are slack they will serve to "pump" oil from the cylinder walls into the cylinder head, as illustrated in Fig. 253. A simple method of checking this fault is shown in Fig. 255. If the rings are slack, or rather if the grooves are worn, it will be necessary to have the latter cleaned out in a lathe to take a wider type of ring.

Scraper Rings.—In the case of some engines, oil consumption can be reduced by drilling a series of small holes round the lower ring groove, as shown in Fig. 255. The holes should be inclined downwards so that the oil scraped down the cylinder wall by the ring tends to run back into the sump. Before adopting this procedure it is well to ask the makers for their approval. When the method is employed better results can generally be secured by using a scraper ring of the type illustrated, and which is conical in shape. Notice the position of this, however; the "narrow" end is toward the piston skirt, and if it is fitted wrongly it will do more harm than good.

Excessive Feed to Rocker Shaft.—Another cause of excessive oil consumption which is generally confined to engines with push-rod operated overhead valves is too great a supply of oil to the rocker-shaft. With oldish engines it is always safe to reduce the flow of oil by reducing the size of the hole in the union attached to the side of the cylinder head. In fact, some makers will supply a special tap for this purpose. The tap has two "on" positions, the barrel being drilled in two diametrically opposite directions. One of these holes is about the same diameter as the feed pipe, but the other is considerably smaller, and the engine should normally be run with the latter in use. Once every few hundred miles, however, the full oil

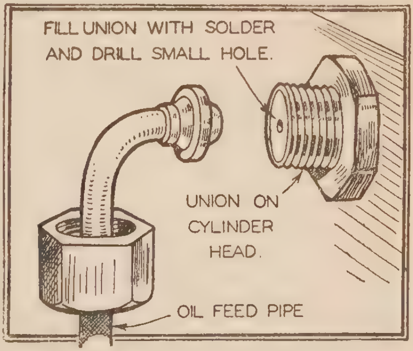


Fig. 256.—Excessive oil consumption on many overhead-valve engines can be cured by reducing the oil feed to the rocker shaft. A simple method of doing this is illustrated above.

flow can be used for a short time so as to " prime " the system.

If the special tap cannot be obtained a modification should be made as shown in Fig. 256. The hole in the union is first filled with solder, and then a $\frac{1}{16}$ inch hole is drilled through the solder. Before running very far after the alteration has been made it will be wise to make sure that the rocker shaft is not being starved, and if it is, to enlarge the hole slightly.

OIL CUP.—A metal or glass receptacle for holding oil used on early cars. It was made in a great variety of forms and was usually placed within sight of the driver in order that he could gauge the amount of oil being fed to the bearings, etc.

OIL FEED.—The distribution and supply of oil either by pressure or gravity to the working parts of the engine, bearings, etc.

OIL LEAKAGE.—*Testing for Oil Leakage.* — There is reason for suggesting that in an appreciable proportion of cases, in which an engine is believed to be " using " a great deal more oil than it should, that the cause is not excessive consumption, as generally understood (*e.g.* the burning-up of oil that has worked up past ill-fitting pistons and piston-rings), but rather that there is a leak from the crankcase or distribution casing, or elsewhere that is unsuspected by the owner-driver.

Leakage of engine oil, it should be remembered, does not always occur while the car stands in its garage. True, there will nearly always be a few or many spots on the garage floor when the car has stood for an hour or more, after a run of sufficient length for the oil to become thoroughly hot. But these spots do not cause excessive oil consumption ; the leaks thus indicated continue, as a rule, for a comparatively few minutes, gradually ceasing as the oil cools down.

Far more serious is a leak that occurs only or mainly while the car is running. Such a leak is probably continuous, and it may be extensive, too, without the driver realising that oil is being lost—it drips on to the road and leaves no sign that the driver can observe.

The point arises, therefore, as to how, if oil consumption seems excessive, one can tell whether the constant need for replenishment of the sump is due to the burning away of the oil above the pistons or to leakage from some point or points on to the road. Here is a plan that has been successfully adopted in a number of cases within the writer's knowledge.

Take a piece of strong white sheeting, large enough to extend underneath the whole of the engine, from side to side and from front to back, and under the gearbox, too. Secure this in position all round by a series of cords, so that it lies under the engine as taut as possible and approximately horizontal. If it sags at the centre, secure it to the crank to prevent this. Then drive the car 15 to 20 miles after the engine has thoroughly warmed up. Upon returning to the home garage remove the sheet and note whether, and if so where, there is a large " blot " of oil, as there will be if leakage has occurred beyond what may be termed normal.

Assume, now, that there is a large patch of oil on the sheet with its centre approximately under the oil pump. Naturally the latter will be held suspect ; but it must not be blamed without question, for the oil may be leaking down from a crankcase joint and dripping off the oil pump. The plan should be, therefore, to clean the crankcase at this point and the oil pump and all engine parts nearby, and then, while the oil is still hot, run the engine at a fast idling speed, watching carefully and continuously to see whether oil can be observed exuding from any point, noting particularly the joints of pipes, if any, leading to and from the oil pump. (It is presumed that the latter is exterior to the crankcase.)

A similar plan should be followed if the blot of oil is under the distribution casing, or anywhere else. Thoroughly clean the suspected point of leakage and all parts around it, and then watch for the leak while the engine is running at a fair speed.

It is important, in fixing the sheet under the engine, not to leave any extensive opening at sides, front or rear ; if there are any—even at the back—air currents while the car is running on the road may cause the drips to fall on the sheet quite a long way from the point of leakage, or to be blown over a large area in all directions. In such case the test will not lead to easy identification of the leaking unit.

OIL MIST.—Name given to the fine spray of oil within the engine which is created by the rapid agitation or splashing of the fluid.

The simpler systems of engine lubrication depend to a large extent for their success upon the presence of this " oil mist."

OILSTONE. — A fine-grained stone, the surface of which after, usually, being smeared with oil, is used for the sharpening of cutting tools, etc.

OPEN CIRCUIT.—See *Circuit.*

OSCILLATING SLEEVE VALVE.—A special type of sleeve valve, comprising only one metal sleeve, which, being given an eccentric motion, controls the entry and exit of cylinder gases through ports arranged in the cylinder wall.

See *Sleeve Valve* and *Valves.*

OSCILLATION.—The moving forwards and backwards of an object within defined limits, as, for example, the motion of a piston within a cylinder.

From the Latin, *Oscillare,* to swing.

OTTO CYCLE.—The four-stroke cycle of operations which produces the power within the cylinder of an internal-combustion engine. So-called after Dr. Nicolas Otto (1833-1891), who introduced it in his " silent " gas-engine in 1876. This four-stroke cycle, however, was first suggested by Beau de Rochas, a French scientist, in 1862. (See *Four-Stroke Principle.*)

OVERALL LENGTH.—Applied to a car, this is its total length—the distance between its foremost projection and the farthest point at its rear.

OVERHEAD VALVES.—Valves which are placed in the top of the combustion chamber and which are actuated either by long tappet-rods, worked by a camshaft below or by means of a camshaft placed above them. (See *Valves.*)

OVERHEATING.—Term generally referring to the point at which the internal temperature of the cylinder prevents adequate lubrication between piston and cylinder, together with other unwanted effects, and so deprives the engine of much of its power output.

OVERHEATING: CAUSES AND REMEDIES.—Overheating may be caused in a number of ways, and a consideration of the causes will naturally suggest a remedy.

When an engine is new the cooling system adopted by the designer and maker can be taken as efficient. But the continued use results in these conditions being upset or at least considerably altered. The continual flow of the water through the jackets to the radiator and back is an essential, and anything which affects this will affect the cooling efficiency, because if the water cannot be kept in fairly constant circulation it does not pass the cooling air in the radiator often enough to reduce its temperature to the required level. This circulation, especially in the case of those systems operating on natural flow, or thermo-syphonic circulation, will be retarded if the water-jackets and the pipes and the radiator spaces get encrusted with lime and other deposit from the water. These deposits, besides restricting the water-way and so retarding the flow, act as very efficient non-conductors of the heat. They prevent the heat from the cylinder-walls reaching the water in the cylinder-jackets. They also prevent the heat of the water in the radiator being transferred to the open air and the cooling stream of air passing through. The effect, therefore, is cumulative, and if the deposit is not removed the matter will get worse, until the engine cannot be operated without the water boiling and being lost in steam. The radiator and jackets and piping should be emptied and filled with a strong solution of soda in hot water. This should be circulated around the system by the simple process of running the engine either normally on the road in course of use or with the engine running more slowly in the garage yard. The solution should then be allowed to remain in the engine for 24 hours (or more if convenient), and again circulated by running the engine for half an hour or so. Then the whole should be emptied out and new rain water fed in. Soft water, rain water or water which has been treated in the household water-softening plant, should be used wherever possible, since it does not deposit chalk and lime, which are the causes of overheating. In the winter do not adopt the method of emptying the system each night to prevent freezing. Use a non-freezing solution. Glycerine in the proportion of 50-50 is suitable. Continually emptying and refilling means the collection of a much larger amount of lime and other sediment. Obstructions in the circulating system will cause overheating. A kink in a rubber-hose uptake pipe may reduce the efficiency of a thermo-syphon system by 30 per cent. to 50 per cent. That is easily remedied.

Valve Clearances.—The clearance between the tappet and the valve may be too great in the case of the exhaust valve, with the result that the valve will open late, will not fully open, and will close early. These three defects will have the effect of keeping the exhaust gases in the cylinder too long. They cannot get away at the right time. When the valve is open it is not open high enough, and the outlet for the hot gases is restricted: when it closes it closes too early—before the piston has reached the top of its scavenging stroke. This latter leaves hot gases in the cylinder, reducing and diluting the gas charge drawn in, and heating it unduly. The remedy for this cumulative trouble is to adjust the clearance between valve stem and tappet to ·003 inch or three-thousandths of an inch.

Ignition Faulty.—An ignition setting which delays—retards—the time of the spark will cause serious overheating. The charge is not ignited till the piston has descended some way down the cylinder. The combustion is not completed by the time the piston rises to push the exhaust gases out. These gases are extremely hot and they burn the exhaust valves and heat up the valve passages unduly, probably, also, so heating the incoming charge by radiation through the body of the casting as to reduce the weight of mixture drawn in. The hot valves will be pitted or they may be distorted. They will not sit tight on their seats and loss of compression and loss on the power stroke (by leakage past the exhaust valves) will cause further loss of power. This late firing may be remedied generally by the driver adopting a more advanced position for his ignition advance and retard lever. The automatic governor may be sluggish through being dirty and having gummed oil on its moving part. It should be washed with petrol and lubricated with thin clock or gramophone oil—not with ordinary machine oil. The ignition timing should be checked by the position of the piston in the cylinder. The contact breaker should break contact (when the ignition is fully retarded) when the piston is at top dead centre, *i.e.* at the top of its stroke. It can then be advanced by the driver when the engine speed rises. The automatic governor, when one is fitted, will advance it. The adjustment will, of course, have to be made while the governor is stationary: which will be correct.

Carburation Faulty.—A carburettor setting which gives a gas mixture too rich in petrol and deficient in air will result in over-heating, because the mixture burns slowly, and the effect is very much the same as in the case of a too much retarded ignition. Most carburettors are designed so that nothing can go wrong with them, the jet sizes being fixed. These carburettors have compensating jets and some have small air-jets in the easy-starting arrangement incorporated. The air jet must be clear. If it gets choked it may upset the mixture, and make it too rich. Carburettors which have a sliding dash pot, pistons, and variable jets by sliding taper needles, may err on the side of giving too rich a mixture if the sliding parts get obstructed so that they drag and do not slide quite smoothly. It is a mistake to lubricate these parts. They should be quite dry and quite clean. If they seem to drag, or "stagger" in movement, they should be taken apart and the moving surfaces thoroughly cleaned with petrol and allowed to dry and then be dry-polished before re-assembling them. Some users of carburettors having taper needles varying the size of the jet orifice have moved the needle back so as to get a larger orifice with the idea of increasing the power. This only leads to too rich a mixture, less power, more carbonisation and more troubles generally. It will be revealed by smoky and pungent exhaust gas and a smelling engine and less power than before.

Crankcase Overheat.—A form of overheating which is experienced in old or badly used engines is that where hot gases get into the crankcase and escape by the breathers at the side of the case. This denotes that hot gases have got past the pistons, they cause overheating of the bearings, the crank case will feel hot to the touch where it should be cool. The oil will be black and impregnated with carbon smoke and fine dust, will smell badly, and will have lost most of its lubricative power. Fumes will come into the body of the car. All this means that new piston rings are called for, and perhaps a regrinding of the cylinder-wall and the fitting of new pistons. It is a condition due to cylinder wear, and is often caused by a too general use of the air strangler in starting, leaving the air strangler on after the engine has started and flooding the carburettor too much, and too often when starting. Wet petrol is drawn into the cylinder and washes away the lubricant from the walls and the piston rings wear away the cylinder rapidly.

OVER-RICH MIXTURE.—See *Rich Mixture.*

OXIDATION.—Term used to denote the combination of materials with oxygen. The rusting of iron forms an example of this process ; so, also, does the burning of the gaseous fuel within the cylinder of a petrol engine.

OXYGEN.—The gaseous constituent of air which supports life and combustion. Without it the petrol engine would be an impossibility. Oxygen is the most widely distributed of all the chemical elements, forming about one-fourth, by weight, of the atmospheric air. See *Air.*

P

PACKING.—Material which is interposed between joints in order to render them liquid or gas-tight. Packings are made in many materials. Usually, however, they include some substance of a fabric nature as, for example, asbestos.

PARAFFIN.—The name given to an oil obtained in the distillation of crude petroleum and also in the Scotch shale industry. It is used, mainly, for burning and cleaning purposes, but under special conditions it may be employed as a motor fuel, particularly in heavy engines.

From the Latin, *Parum affinis,* little affinity—in reference to the chemical inertness of paraffin liquids.

PARAFFIN PAPER. — Good quality paper which has been saturated with paraffin wax. It is used in the construction of electrical condensers which are fitted to magnetos and ignition coils.

PARAFFIN WAX.—A wax-like mixture of solid hydrocarbon substances derived from crude petroleum. It is also produced by the Scotch shale industry. Having high insulative properties, paraffin wax enters into the construction of many articles of electrical use.

PARALLEL-PIN-ON DIFFERENTIAL.—See *Straight Tooth Differential.*

PATTER.—A term employed to describe a species of up-and-down or see-saw movement of the car wheels caused by the axle oscillating across its centre. (See *Steering.*)

PENTANE.—Chemical formula : C_5H_{12}. A colourless hydrocarbon liquid. Boiling point, 37° C. Specific gravity, 0·627. A constituent of the lightest motor fuels.

PETROL. — The colourless, highly-inflammable liquid obtained by the distillation and refining of crude petroleum. It is a mixture of a large number of hydrocarbon liquids.

The name "Petrol" was first applied to motor-spirit by Messrs. Carless, Capel & Leonard, of Hackney Wick, London, about the year 1896.

PETROL CONSUMPTION, IMPROVING.—Running costs form one of the heaviest items on the motorist's bill, so that any method of reducing them is worthy of special attention. It is, therefore, always worth while to experiment with a view to reducing petrol and oil consumption as much as possible. The object of the present section is to suggest simple methods by means of which greater running economy can be secured.

Although really quite obvious, it is not always realised that economy goes hand-in-hand with efficiency, so that if the car is made more efficient, greater economy in running expenses is automatically secured. Because of this it is well worth while to examine the superficial parts of the car before taking drastic steps to reduce petrol consumption by apparently obvious methods such as reducing the size of the carburettor jet. First of all, for instance, it pays to make quite sure that all the brakes "free" properly and that the car offers the least possible amount of resistance to motion.

Tractive Resistance.—Take the car on to a smooth and level stretch of road and find how much energy is required to push it from a stationary position. With most light cars very little effort should be required and the car should run quite easily. If any of the brakes happen to be touching the drums a slight "rubbing" sound will probably be heard and the particular brake at fault can easily be found by "ear."

Another way of checking any resistance is to push the car up a *very slight* gradient; there should be no difficulty in moving it, whilst it should "return" by its own weight. When it is found that the car does not move freely, although it has been ascertained that the brakes are perfectly free, the axles and wheel mountings should be examined for wear and lack of lubrication. Worn ball- or roller-races can cause appreciable friction which will naturally increase petrol consumption. In making these preliminary examinations the tyres must not be overlooked, since if they are at too low a pressure they will exert a noticeable amount of resistance.

Air Leaks.—Air leaks into the

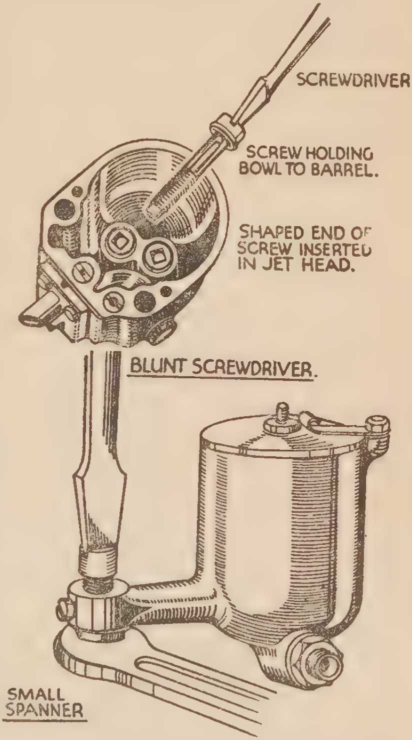

SCREWDRIVER
SCREW HOLDING BOWL TO BARREL.
SHAPED END OF SCREW INSERTED IN JET HEAD.
BLUNT SCREWDRIVER.
SMALL SPANNER

Fig. 257.—Diagram showing methods of removing carburettor jets. In the upper illustration an ordinary bolt is used, the end being filed square. The lower illustration shows the removal of the jet from a Smith single-jet carburettor.

cylinder-head, or between the carburettor and induction pipe, can seriously reduce the m.p.g., although in some instances such leaks would have the reverse effect. In any case air leaks can give rise to trouble in other directions—over-heating, bad starting, and slow-running, for instance—so they should certainly be cured. It is not always an easy matter to trace air leakages, but in many cases they may be detected by the "hissing" or periodic "breathing" sound which is heard when the engine is running very slowly. Their exact location can then be traced by holding the (moistened) back of the hand near to the induction pipe and the cylinder-head gasket. If some doubt is then felt a drop of oil should be put on the spot where it is thought that the leakage occurs; bubbles and "sizzling" noises will confirm the leakage. This test can be applied to most parts of the engine, and it is particularly useful in regard to the plugs where they are mounted vertically. Do not overlook the fact, however, that a certain amount of bubbling will in any case be noticed if the cylinder-head is hot, due to the oil boiling.

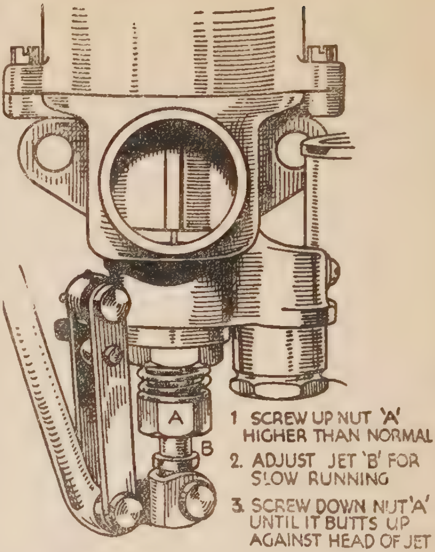

A
B
1 SCREW UP NUT 'A' HIGHER THAN NORMAL
2. ADJUST JET 'B' FOR SLOW RUNNING
3. SCREW DOWN NUT 'A' UNTIL IT BUTTS UP AGAINST HEAD OF JET

Fig. 258.—In a needle jet type of carburettor the mixture adjustment is shown above.

Carburettor Jet Sizes.—It is frequently possible to increase the mileage per gallon of petrol by changing the carburettor jets, where interchangeable jets are used, or by fitting a new jet needle in the case of other carburettors. A smaller jet, or larger needle, will naturally reduce the amount of petrol—in proportion to the air—fed to the choke tube and thence to the engine. It might therefore be considered that a smaller jet will always give better consumption, but this is by no means true. If, for instance, the jet is smaller than some particular minimum, engine efficiency will seriously be reduced, with a result that the petrol consumption must be increased. It is therefore worth while to experiment with two or three different jets, noting the car's pulling power and the petrol consumption in each case. The method of changing the jet naturally depends upon the type of carburettor, but some of the commoner methods are illustrated in Fig. 257. When the carburettor has a needle jet the usual method of adjusting the jet opening is by turning the hexagon nut shown in Fig. 258; screwing the nut upwards toward the body of the instrument reduces the jet size, whilst unscrewing makes the opening larger. This point will more readily be followed by looking at the sectional drawing in Fig. 359.

A number of the jet-type carburettors have a slow-running device in addition to the main jet and an example of this is given in Fig. 260. In this case the knurled knob is screwed in or out of the tubular body to vary the mixture strength, whilst a lock-nut is provided for use after the optimum setting has been found. It is best to adjust the slow-running jet, or the needle-jet arrangement shown in Fig. 259 when the engine is thoroughly warm, and the adjustment should be made so that the mixture is as weak as possible (jet small) consistent with a steady tick-over.

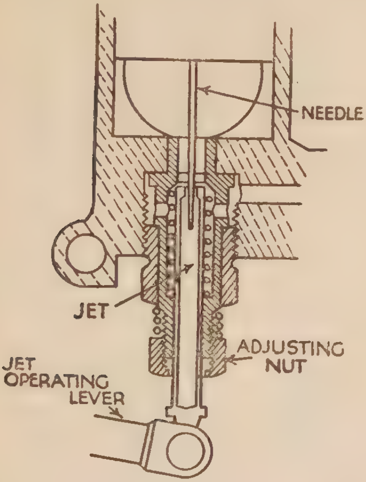


FIG. 259.—A section through a needle jet of the type represented in Fig. 258. The position of the tapered needle in the jet can clearly be seen.

The Choke Tube.—The jet is not the only part of the carburettor that can influence petrol consumption, for the choke tube is equally important. In a way this acts in the opposite manner to the jet, since an increase in its size causes a smaller amount of petrol to be drawn from the jet, and *vice versa*. The reason is that a larger choke-tube area has the effect of reducing the suction on the jet. The position of the choke tube in a typical carburettor is shown in Fig. 261, from which it will be seen that the tube is held in position by means of a small grub screw. To change the tube it is necessary first of all to remove the carburettor from the engine, remove the throttle valve, and then to slacken the screw, after which the tube can be withdrawn. It will be found to fit tightly and care should therefore be taken not to damage it by applying undue force. As the size of the choke tube is different for practically every model of car it is impossible to say what size should be tried in particular cases. The general rule is, however, that a slightly larger choke (in conjunction with the appropriate jet) will increase the m.p.g. of petrol. In any case it is worth while to consult the makers of the car in regard to the most suitable sizes of jets and chokes if this information is not given in the instruction book.

Checking the Exact M.P.G.—Reference was previously made to the idea of comparing the m.p.g. with various jet and choke sizes, and some further information is called for in regard to this matter.

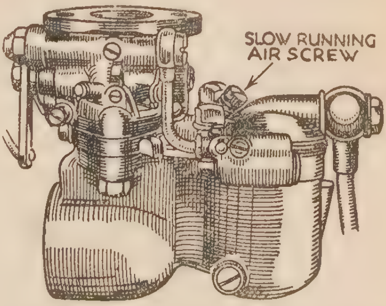


FIG. 260.—Showing the slow-running adjustment on a typical carburettor.

It is not good enough to suppose that there is about a gallon of petrol in the tank, fill up by buying another four gallons, go for a run of a certain number of miles and on return to assess the amount of petrol left in the tank and to base the m.p.g. calculations upon the figures so determined. Things must be done far more accurately than this, and the best method is to disconnect the petrol pipe from the gravity tank, autovac or petrol pump and allow the engine to run until it stops due to lack of petrol. A small supplementary "tank," which can be made from an oil-can, should then be attached to the dashboard at approximately the same height as the normal petrol-supply vessel. The carburettor can then be attached to the new "tank" into which a carefully measured quantity of petrol (a pint or a quart will usually be found most convenient, according to the size of the car) is poured.

Next take an accurate note of the speedometer reading, start up and run until the petrol is exhausted, after which another note must be taken of the speedometer reading. After adjusting the carburettor the same test should be repeated on the *same stretch of road, at the same speed and under similar weather conditions, so that an exact comparison of mileages can be made.* Incidentally, a few details of construction for the auxiliary tank are given in Fig. 262.

The same tests as those just described can readily be made after other adjustments have been made, and also with different brands and grades of spirit in order to find which is most suitable.

The Ignition System.—Sparking-plugs and the ignition system in general have a pronounced effect upon m.p.g. and it is well worth while carefully to adjust the points and to check the spark gap (for method, see under *Magneto* and *Ignition*, on earlier pages) at intervals of 1,000 miles or so. At the same time the plugs should be thoroughly cleaned, either by removing the central electrode, when detachable, and wiping with a petrol-soaked rag or by means of one of the special outfits which have recently been installed by many service agents.

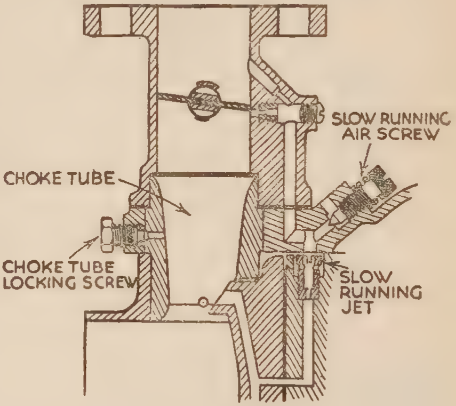


FIG. 261.—This section shows the slow-running jet and choke tube.

Driving Methods.—The method of driving the car governs the petrol consumption to a surprising extent, and a decided saving in running costs can be effected by attending to this point. Over-use of the strangler when starting-up, sudden and rapid acceleration and driving fast all reduce the m.p.g. These things should consequently be avoided as much as possible. Every car runs most efficiently and therefore most economically at a particular engine speed, so that it pays to run the engine at that speed as much as possible. No figures can be given, but the driver can usually estimate the speed for himself by observing when the car appears to run most "easily," or by consulting the "power curve" which most makers will supply upon request.

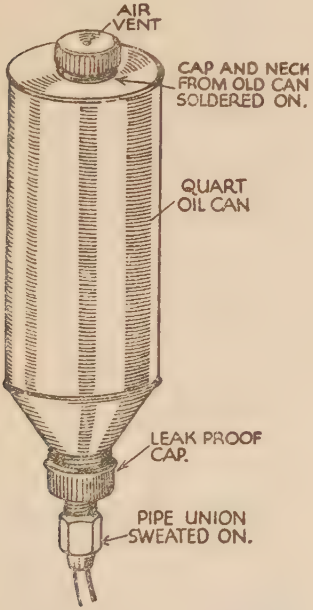


FIG. 262.—A useful auxiliary fuel tank for checking consumption can easily be made as shown above.

PETROLEUM. — The naturally occurring mineral oil from which commercial petrol is distilled.

Petroleum has been known for centuries, but it was not produced in any commercial quantity until the year 1859. From the Latin, *Petra*, rock; *Oleum*, oil.

PHOSPHOR-BRONZE.—An alloy containing copper, tin and phosphorus and sometimes traces of other metals such as zinc, lead and iron. Usually it contains from 80 to 90 per cent of copper, 6 per cent of tin and about 0·03 per cent of phosphorus, together with one or more of the metals enumerated above.

Phosphor-bronze is a yellowish looking, fine-grained metal which is extensively used on account of its good-wearing properties as a lining metal for bushes and shaft bearings.

PI (π).—This, the Greek letter P, is the symbol universally employed in all mathematical and engineering calculations for the important ratio between the circumference of a circle and its diameter.

The precise value of this ratio has never been worked out. For ordinary engineering purposes, however, it is taken as $\frac{22}{7}$ or $3\frac{1}{7}$, 3·142, or 3·1416.

PIN.—A term applied to denote a variety of variously shaped pieces of metal which are used in the motor industry and in engineering practice generally in order to secure mechanical parts in their correct position.

PINKING.—A name which describes a characteristic light tapping sound which is generally in evidence when the engine is under heavy load or when it is accelerating.

Pinking is a species of detonation. It is caused by varying factors, being especially prone to occur when the ignition is too far advanced.

PISTON.—A circular plate or mass of metal so contrived that it works with an oscillating or up-and-down movement within a hollow cylinder.

The principle of the piston is the invention of Dr. Denis Papin, a French physician of the mid-seventeenth century, who was living in England at the time of his experiments.

THE PISTONS, CONNECTING RODS, AND BEARINGS.—If the engine is performing satisfactorily, the oil consumption is perfect, and there is no sign of mechanical knock, the pistons and connection rods should be left alone. If, however, the oil consumption is excessive, the pistons will give audible evidence of their condition by a loose rattle emanating from the cylinder when the engine is running. There will, too, be considerable loss of power.

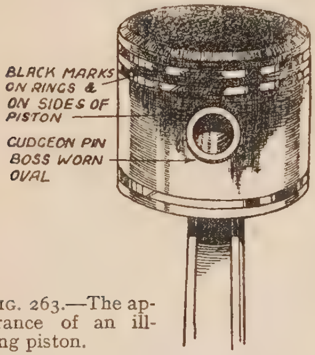

BLACK MARKS ON RINGS & ON SIDES OF PISTON
GUDGEON PIN BOSS WORN OVAL

FIG. 263.—The appearance of an ill-fitting piston.

Removing the Pistons.—In order to remove the pistons it will be first necessary to remove the sump, and unless the car can be jacked up to a sufficient height to permit of this operation being carried out conveniently, it will be necessary to place the car over the pit; carefully remove the nuts securing the sump, keeping them in the order of removal. Note also the order of any washer bars used on sumps of the pressed steel type. A cork washer is interposed between the sump and the crank-case, and if this joint can be broken without damage to this washer, so much the better. On no account should a broken washer be replaced, otherwise oil leakage will result. It is hardly necessary to state that all oil should be drained from the sump before removing. Removal of the sump will expose a gauze filter which should be removed, thus revealing the big end, the oil sump, and the camshaft.

This latter should be examined to make sure that none of the cams are worn, if the peaks of the cams are badly worn the valves will not receive the correct amount of lift, which will result in misfiring and loss of power.

Removing the Big Ends.—It will be noticed that the big ends of the connect-rod are secured to the crankshaft by split bearings secured by two bolts; the nuts of which are split pinned. Remove the split pin and then slacken off the nut; mark each big-end bearing so that it is replaced in exactly the same way. It is sufficient usually to mark the front only. After removal of all the big ends it will be possible to draw the pistons through from the top of the cylinder. Mark the front of each piston before removal.

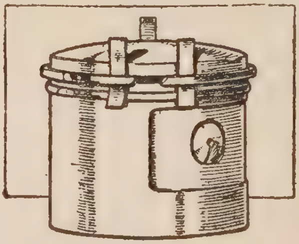


FIG. 264.—Method of removing Piston Rings.

Examining the Pistons.—If the pistons are badly worn they will certainly be covered with a brown carbon deposit. Not necessarily all over, but certainly in large patches. These patches will indicate that the gas has been blowing by the pistons. The only remedy with a worn piston is replacement. It might be that the cylinder bores

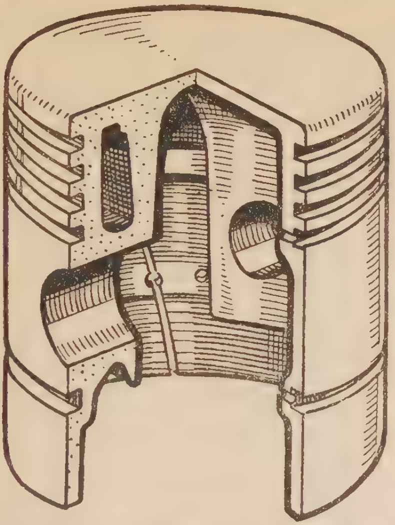


FIG. 265.—Worldwin Piston. Large area of internal cooling surfaces. Split skirt.

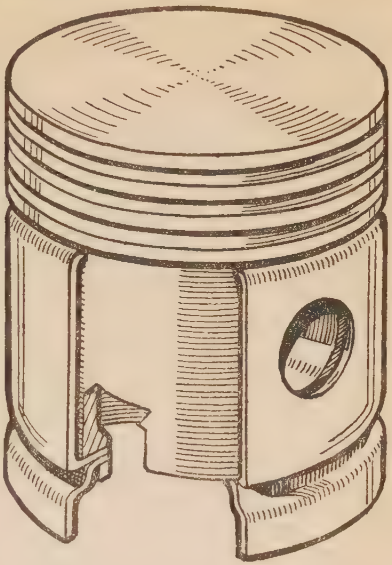


FIG. 266.—Zephyr Piston which has a light steel outer covering.

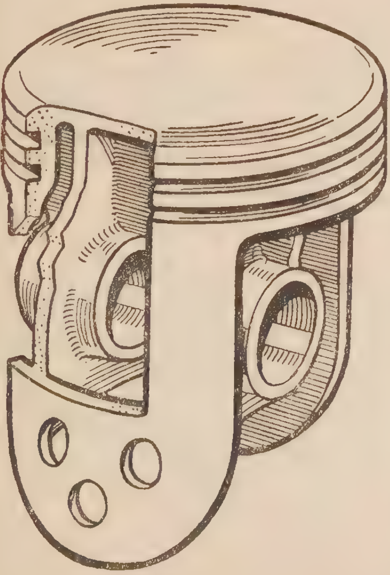


FIG. 267.—Ricardo Slipper Piston.

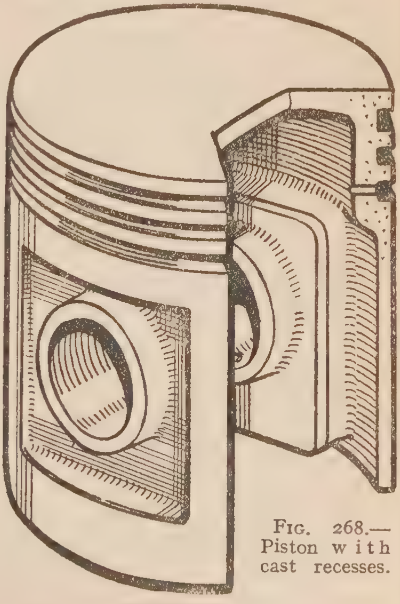
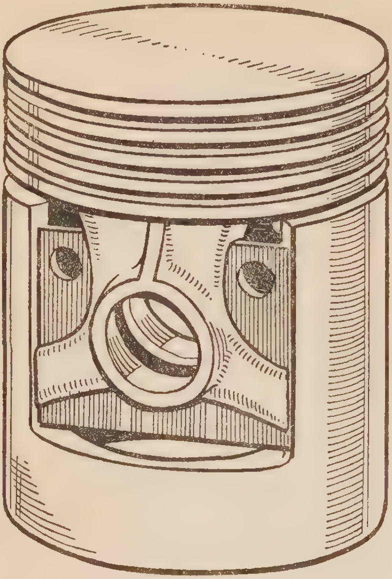
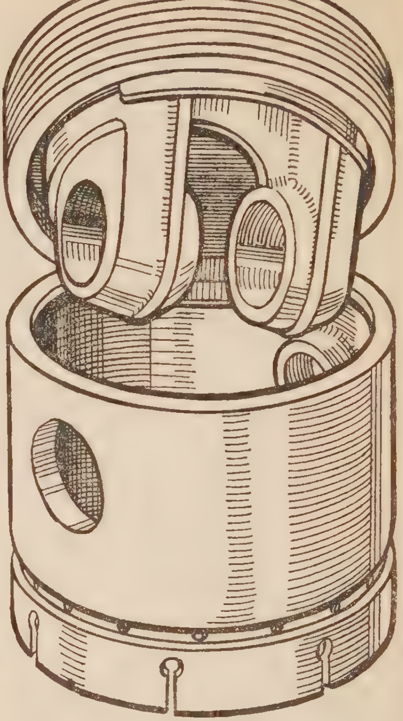


FIG. 268.—Piston with cast recesses.

PISTON DESIGN 2





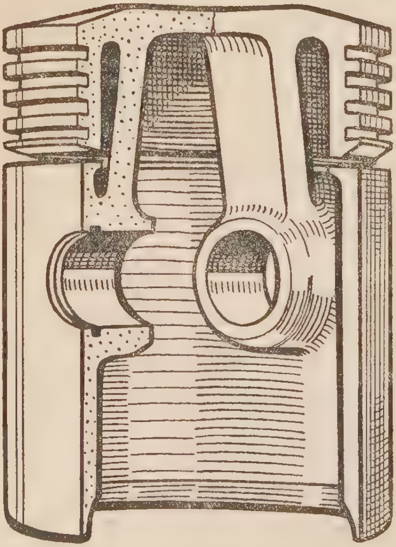


Fig. 269 (*Top left*).—Invar Strut Piston.

Fig. 270 (*Above*).—Bi-metal Piston with alloy head and steel skirt held together by gudgeon pin.

Fig. 271 (*Left*).—B.H.B. Self-adjusting Piston (Head of Piston detached from the skirt except for struts).

themselves are badly worn or are oval, in which case re-boring may be necessary. You can easily check the bores with a pair of callipers for roundness. If any of the pistons are cracked, but otherwise usable, again drill a small hole at the end of the crack to prevent it extending (*see* Figs. 272 and 273).

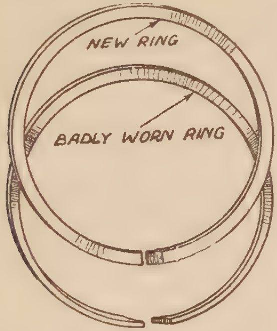


FIG. 272.—An Old Ring and a New. Owing to "springiness," rings wear thin on one side only, as shown.

Removing Piston Rings.—The time-honoured method of removing piston rings is shown in Fig. 264. Carefully slide three pieces of hack-saw blade round each ring and slide it off, starting with the top ring, then the second, and finally the third. In replacing rings, remember to fit the bottom ring first by sliding it over the bottom of the piston.

Piston Rings.—It is a good plan and one that will promote the general running efficiency of the engine thoroughly to examine the piston rings each time the cylinder-head and sump are removed for the purpose of decarbonisation (*see* Fig. 263).

While it may be absolutely necessary to fit one or more new rings where the old ones are chipped or broken at the portions of the ring adjoining the gap, new ones may be required for one or more of the following reasons: surface pitting or deeply scratched by vertical lines caused by overheating or excessive carbon deposits in ring grooves. Uneven bearing caused by the ring becoming deformed. Loss of spring caused by the rings becoming overheated. Worn on the outside diameter to such an extent that the gap is unduly enlarged. Loose in groove.

Testing Rings.—The first item needs no comment, and uneven bearing is easily detected by the presence of discoloured patches on the surface of the rings which contrast with the bright portions which have been making contact with cylinder-walls. To decide the other three items it is essential that the rings shall be removed from the piston. This is best accomplished with the aid of a pair of piston-ring tongs or one of the several ring-removing tools, failing the possession of which, resort may be made to the time-honoured strips of thin metal.

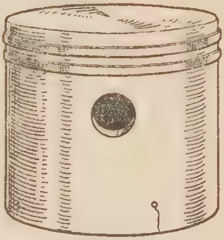


FIG. 273.—If the Piston Skirt is cracked, drill a small hole at the end of the crack to prevent it spreading.

Loss of spring is distinguishable by compressing the springs in the hand, and any of them feeling at all "flabby" should be discarded. Such a ring, when compared with the others would almost certainly be smaller in diameter when free (Fig. 272).

Worn rings may be discovered by entering them one at a time in the mouth of the cylinder, as shown in Fig. 278, taking care that the edge of the ring is parallel with the bottom face of the register, pressing the ring into the bore by means of the piston. The gap for expansion should not exceed ·005 inch, which may be checked approximately by inserting a cigarette card in the gap.

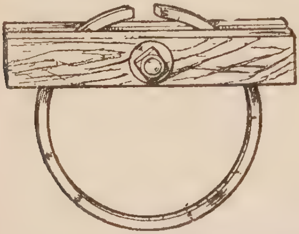


Fig. 274.—A Holder for use when filing rings.

The fit of the rings in the grooves of the piston can be determined by inserting the rings therein, as shown in Fig. 276. It should not be possible to insert more than a piece of thin paper between the edge of the ring and the groove. Should much wear be apparent, examine the grooves, and in all probability it will be noticed that they present the appearance shown in the enlarged view in Fig. 276. In such a case the piston grooves will require returning to take wider rings.

Where new rings are required it will be best to remove the piston from the connecting-rod, as matters will be greatly facilitated by doing so.

Fitting New Rings.—The new rings should be tried in the cylinder bore to note if there is sufficient clearance between the ends of each ring for expansion. The condition of the cylinder bore should also be noted as it is probable that the diameter will be perceptibly larger from a distance governed by the limit of travel of the rings than the mouth of the cylinder. Where such a condition exists the rings should be tried above this point. The average amount of gap necessary for expansion is ·005 inch, which may be tested with a feeler gauge or with a thin visiting card which is approximate to this dimension.

Should the gaps require enlarging, the excess metal should be removed with a fine cut flat file, taking care to maintain the original angle of the cut and also to preserve the flat surface. Fig. 275 shows a convenient method of holding the rings to avoid breaking or vice-marking them while filing.

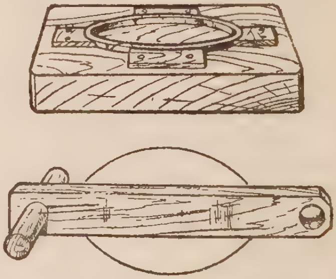


Fig. 275.—(*Above*) a Holding-down Block for Rings which require to be made thinner, and (*below*) Handle which is attached to the gudgeon-pin when lapping rings.

The width of the rings should be such that they should push into the ring grooves without slackness, but without trace of binding. If they are inclined to bind, they should be rubbed down on a sheet of fine emery cloth, tacked on to a flat piece of board, until a correct fit is obtained. By the way, see that the emery cloth is quite dry as if at all damp the sharp ring edges will scrape the abrasive from the cloth backing. For this operation the ring should not be mounted on a holder made from a flat piece of wood with small blocks attached, or nails with the heads cut off driven in to keep it in place (*see* Fig. 275).

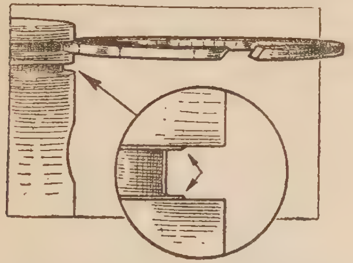


FIG. 276.—Testing a Ring for fit in its groove. Inset shows steps worn by badly-fitting Ring.

The rubbing-down should be done with a circular motion and lightly applied pressure.

After assembling the rings on to the piston, push the piston (without lubricant), up and down a few times in the cylinder. Remove and examine the rings for bearing mark made by contact with the cylinder-wall. These should be fairly even and close together round the whole circumference. If such a condition does not exist, it is advisable to lap the rings into the cylinder. For this purpose a wooden handle similar to that shown in Fig. 274 will help considerably. A very fine abrasive should be used for lapping, paste metal polish will cut plenty fast enough, and at the same time leave a good surface. A small quantity of paraffin applied to the cylinder from time to time during the applying process will make the work easier. Avoid using an excess of paste, and move the pistons backwards and forwards with a slight twisting movement. When a good bearing on all the rings has been obtained, clean the cylinder and piston well with petrol. It is advisable to remove the rings from the piston to clean the grooves well out.

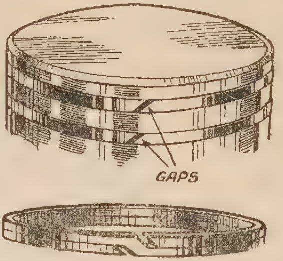


FIG. 277.—Compression Loss occurs if the Piston Ring Gaps are above one another, and (*below*) Ring designed to avoid Gap Losses known as the Clupet.

PISTON CROWN.—The head of the piston which receives the full force of the explosion within the cylinder.

PISTON RINGS.—Narrow, split rings, usually of cast-iron, which are fitted around the piston and which, by making a sliding pressure-contact with the cylinder walls, prevent the escape of gas past the piston.

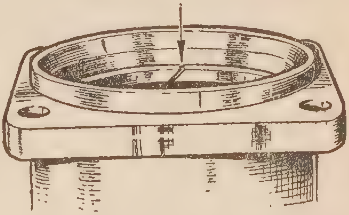


FIG. 278.—Testing the Gap at the ends of the Ring.

PISTON SKIRT.—The lower sides of the piston.

PISTON SLAP.—A peculiar and characteristic metallic slapping noise within the cylinders due to slight rocking motion of ill-fitting pistons.

It occurs at times in racing engines fitted with aluminium pistons which are given an excessive clearance in order to provide for their expansion when hot.

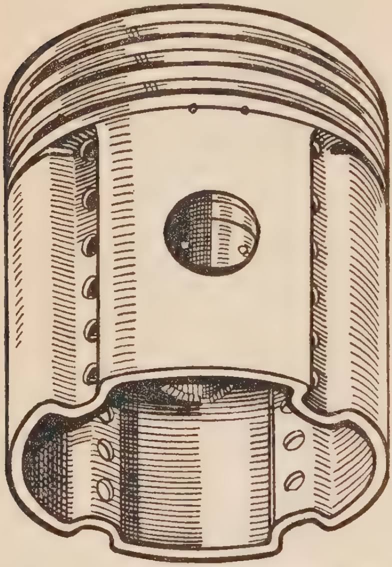


FIG. 279.—Aerolite Compensating Piston.

PISTON STROKE.—See *Stroke.*

PITCH.—A mechanical term used in connection with screw threads to denote the distance from the centre of one thread to the centre of the adjacent thread.

A black, semi-hard material derived from the distillation of coal tar, which, on account of its insulating properties, is employed in the construction of certain types of batteries and, also, for the impregnation of insulating cable coverings.

PLAIN BEARING.—The simplest type of bearing—a shaft revolving within a ring of metal which is slightly greater in diameter than the diameter of the shaft.

Plain bearings of this type generally comprise a steel shaft revolving within a ring of some tough metal such as phosphor-bronze or phosphor-bronze surfaced with white metal.

PLAIN CUT.—A term usually applied to the ends of some piston rings which are cut diagonally across.

See *Step cut.*

PLANETARY GEAR.—A form of gearing, common in change-speed mechanisms in which small pinion-wheels revolve sun-and-planet-wise, around a larger central wheel.

PLATE CLUTCH.—A popular form of clutch of which there are many types. Essentially, it comprises a series of two or more friction plates — the " driving " plates and the " driven " plates—which are maintained in close contact by means of a spring or set of springs. In this condition the clutch is " in."

Clutches of this type are " withdrawn " by pressure on a pedal, which, by means of a lever mechanism, causes a rod or " thrust pin " to press back the clutch spring, thus relieving the pressure on the plates.

PLATINOID.—A form of nickel silver containing about 2 per cent. of tungsten. It is used for the making of electrical resistance elements.

PLATINUM.—A hard, lustrous, not easily fusible metal, which is unaffected by most agencies. On account of its scarcity and the demands which are made for it, the metal commands a very high price.

It is used for tipping the contact-breakers of coils and magnetos, and for many other electrical purposes.

PLATINUM TUBE.—See *Tube ignition.*

PLUGS.—On an average car the sparking plugs constitute only about one three-thousandth of the total weight, yet if their dimensions are only very slightly unsuited to the particular engine or if they develop a quite invisible fault, the whole car may be put out of action.

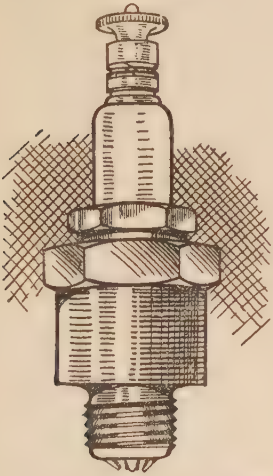


FIG. 280.—A typical plug suitable for average engines.

The plugs are required to give some 10,000 sparks for every mile the car travels. Moreover they have to perform this function under such severe conditions as rapid variations of temperature from below 100 degrees C. to have 2,000 degrees C. and sudden jumps in pressure from a partial vacuum to positive pressures above 200 lb. per square inch. The fact that the modern plug performs its very critical duty under such exacting conditions and gives so little trouble is eloquent testimony to the excellence of design and manufacture. Yet just because it is so good the plug has a special claim to the very little attention it requires.

A plug is made up of three main parts, the central electrode, the insulator and the body. The high-tension current from the magneto or coil is delivered at the correct intervals to the central electrode and the body. If every condition is satisfactory the electric circuit is completed by a spark jumping from the electrode to the body and thus igniting the mixture.

There is a common fallacy that given a choice of two paths, an electric current will always take the easier. This is not so; it will always take both but the amount of current in each circuit will vary inversely as the resistance.

Again, it is usual to divide materials into two classes—conductors and insulators, iron and porcelain being examples of these classes respectively. Actually all substances are conductors to the greater or less

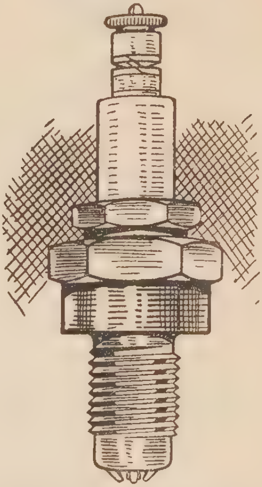
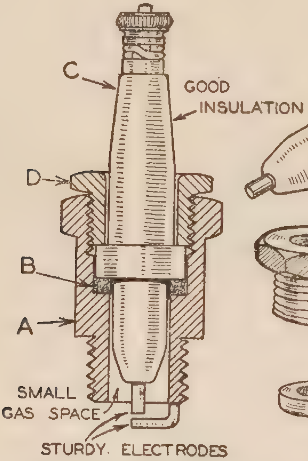


FIG. 281.—A similar plug but with a longer "reach" to accommodate certain castings so that the plug points reach the correct position in the combustion chamber.

extent, what we call an " insulator " being merely a very bad conductor.

Thus the current will always be divided between the spark and a flow through the insulating material, usually porcelain or mica. The latter are such good insulators, or bad conductors, that the flow through them is, or at least should be, quite negligible. But it is readily seen that if the insulator becomes coated with any conducting material the flow of current in this part of the circuit may not be of negligible proportions and while it may still be insufficient to stop the spark passing across the correct gap it may rob that spark of much of its energy and engine efficiency will suffer.



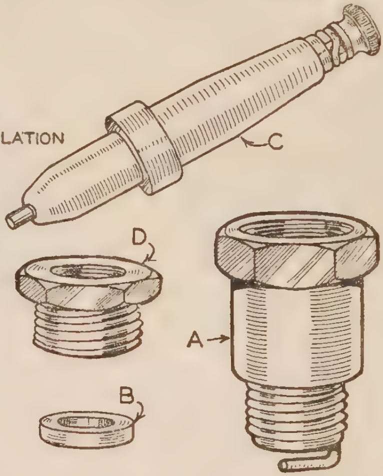


Fig. 282 (*Left*).—Section of good plug, showing its typical features (*i.e.*, good insulation, small gas space, massive electrode).

Fig. 283 (*Right*).—Showing detachable type of plug, the central portion of which comes apart for cleaning.

The chief enemies of plug insulators are moisture and carbon, the former may be deposited on that part of the insulator which is outside the engine while the latter deposit occurs within the cylinder.

Examine the Insulators.—The plugs should, therefore, be examined periodically and the insulators cleaned, a gentle rub with a petrol-soaked cloth is a good plan. In most engines the plugs are well protected from moisture, but if not the matter should receive attention at once. Small rubber caps are available for plugs which are liable to this source of trouble.

If the plugs show undue signs of carbon deposit a change in the type of plug is indicated. This matter is dealt with below.

Importance of Gap.—While the plug is being examined the spark gap should be checked. This is the distance between the central electrode and the nearest point on the plug body. For touring cars this distance should be about 0·02 in. or twenty thousandths. It is best tested by means of a feeler-gauge and should be adjusted by bending the little point, or points, on the plug body. For racing cars or cars which are normally driven very fast it is usual to make this gap rather less and in some cases it is reduced to as little as twelve thousandths. In any case all the plug gaps should be alike.

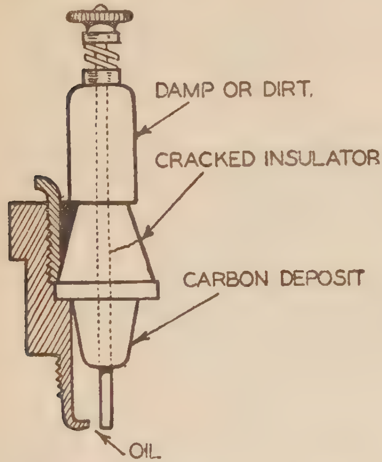


FIG. 284.—Sectional view through a sparking plug showing common causes of failure.

It should not be assumed that the reduction in the plug gap is the only difference between plugs suitable for touring and racing cars respectively. Every plug has, so to speak, two masters whose demands are diametrically opposed. They are oil and heat.

If a plug runs too cool, oil will form on it and in extreme cases the plug becomes "oiled up," that is, so much oil accumulates between the points that the spark cannot pass and the engine "misses" on that cylinder. If the case is not quite so bad as this the oil chars and ultimately the deposit of carbon on the insulator reduces the resistance of the latter and weakens the spark.

By causing the plug to run at a higher temperature any oil or carbon is burnt off and the insulation is thus kept clean. If on the other hand the plug temperature gets too high, while it keeps itself clean, the points rise in temperature until they get red hot and pre-ignition occurs, that is, the mixture in the cylinder is ignited before the correct time, resulting in a serious loss of power.

Ask the Makers.—Controlling the temperature of a plug in order to avoid both these evils is a matter which has involved much research work by those concerned and the private motorist will be wise to avail himself of this specialised knowledge and follow the advice of the makers. A plug, no matter how cheap it is to buy, is dear if it is not suited to the engine for which it is required. The running temperature of a plug is determined by the air space within the plug and by

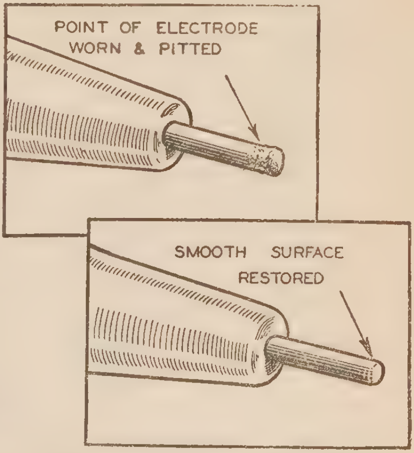

POINT OF ELECTRODE WORN & PITTED
SMOOTH SURFACE RESTORED

FIG. 285.—Detail of plug electrode. This should not be pitted (1st illustration); if so, it should be rubbed with emery until a smooth surface is again obtained (2nd illustration).

the length of insulation between the central electrode and the seat on which it is secured to the body, the greater this length the higher the temperature at which it will run.

Generally speaking the plugs of touring cars are more likely to suffer from oil than heat, while those in racing cars have to be safeguarded against running hot rather than an excess of oil, hence the difference in type of plug employed.

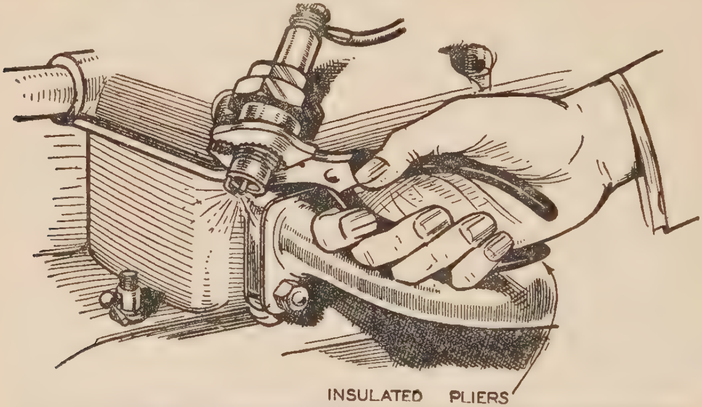


Fig. 286.—Testing insulation of plug by holding it with insulated pliers against side of engine.

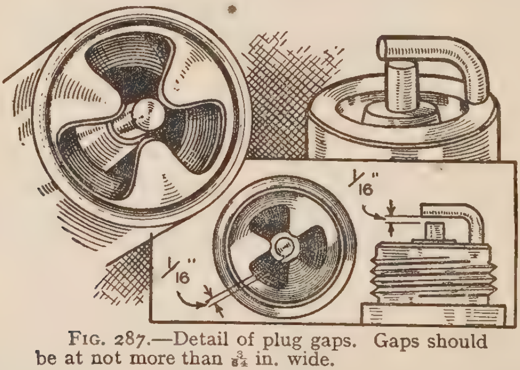


Fig. 287.—Detail of plug gaps. Gaps should be at not more than $\frac{3}{64}$ in. wide.

If the behaviour of a plug is doubted it is a common practice to remove it from the cylinder and while it is connected to its high tension cable and is resting on its side in contact with the engine, to rotate the engine by means of the crank handle and watch if a spark passes. If it does, it proves that the current is reaching the plug but it is not a final proof that the plug is all right, for the resistance between the plug points is much less at atmospheric pressure than at the pressure prevailing on the compression stroke of an engine. A minute crack in the insulation might take so much energy from the supply that no spark would pass at high pressures while one would be visible at the pressure of the atmosphere.

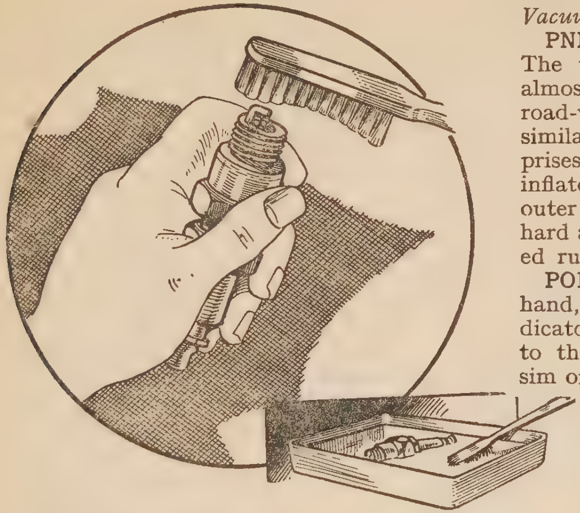


FIG. 288.—Cleaning plug by means of tooth brush or wire brush and bath of petrol.

In this connection the insulating member of a plug should always be handled with gentle care, as it is actually a delicate component which is easily damaged and such damage may cause serious inconvenience.

PLUG ELECTRODE.—See *Electrode.*

PLUMBAGO. — See *Blacklead, Graphite.*

PLUNGER.—This term usually denotes a small piston provided with a hand-operating stem and knob, which is used as a forcer of liquids in small pumps, etc.

PNEUMATIC BRAKES.—Brakes of this type function in virtue of long conduits or pipes in which a liquid is compressed. The operating pressure of the driver upon the brake control is transmitted along the pipe-line to a piston or plunger contained in a liquid-tight cylinder. In this manner the necessary movement of an expanding or contracting brake-band is effected. (See *Vacuum Brakes.*)

PNEUMATIC TYRE.—The tyre used nowadays almost universally for the road-wheels of cars and similar vehicles. It comprises an inner rubber tube inflated with air and an outer protective cover of hard and specially patterned rubber. (See *Tyres.*)

POINTER. — A small hand, needle, or other indicator usually attached to the operating mechansim of a recording instrument to enable an accurate estimate of the degree of movement of the inner mechanism to be made. For example, the hand or pointer fitted to an ammeter, a speedometer, or other measuring instrument. (See also *Speedometer.*)

POLE.—The terminal of a battery, accumulator, dynamo, magneto or other electricity generating instrument. All such devices have two poles or terminals—a " positive " one and a " negative " one.

See *Positive pole, Negative pole.*

POLE FINDER. — An electrochemical device used for the purpose of ascertaining the polarity of a battery or electrical circuit.

Pole-finding paper is chemically prepared paper which is sometimes used for the same purpose.

POLE PIECES.—Name given to pieces of soft iron, having one surface concave, which are attached to the lower, inner sides of magneto or dynamo magnets, and which, by forming a " tunnel " for the armature to rotate in, concentrate the magnetic flux upon the latter member. (See *Magneto*.)

POPPET VALVE.—Name given to the ordinary type of valve employed in car engines, *i.e.* to the valve consisting of a dome-shaped head on the end of a metal stem. So-called on account of the popping noise which it creates during its operation. (See *Valves*.)

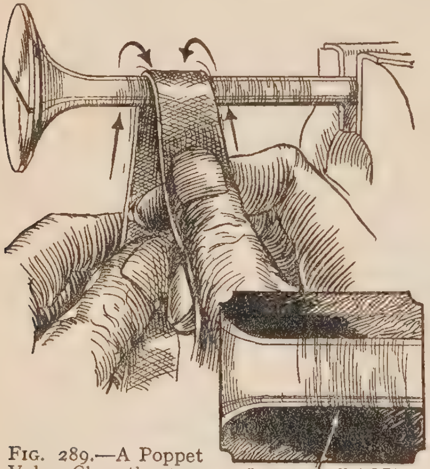


FIG. 289.—A Poppet Valve. Clean the stem occasionally to prevent it sticking in its guide.

SECTION OF STEM ENLARGED, SHOWING SCORES CAUSED BY THE ABOVE METHOD OF CLEANING

POPPING.—See *Back-fire*.

PORCELAIN.—Fine white earthenware, semi-transparent, and usually glazed. It is a very high electrical insulator, being unaffected by weather or other influences. Used to a great extent in the insulation parts of sparking-plugs and other electrical devices.

POROUS HEAD.—Name given to a faulty condition of the metal of the combustion chamber of a cylinder, the metal developing a semi-porous condition and allowing slight leakage of the compressed gas through it. Cure is impossible, but, fortunately the trouble is a rare one.

PORT.—A passage or opening leading to the interior of the cylinder through which gases are drawn into or expelled from the latter. Thus the terms, *Inlet Port* and *Exhaust Port* of a cylinder.

POSITIVE POLE.—Applied to a battery or accumulator, this is the terminal or electrode *from* which the current flows along a circuit connected to the cell. It is denoted by the sign +.

POTENTIAL.—An electrical expression referring to the power of a current of electricity to do work. In many respects, the term is really an abbreviation of the expression "potential energy."

POTENTIAL ENERGY.—The power of performing work which a body possesses in virtue of its position.

A car running down a steep hill with its engine switched off, has, at given instant, a reserve of potential energy which is proportional to its position relative to the bottom of the hill.

POWER.—A term which should be distinguished from *force*, as the two are not synonymous. Power is best described as the *rate of doing work*. In other words:

$$\frac{\text{Work}}{\text{Time}} = \text{Power}$$

Conventionally, power is measured by the energy which is necessary to raise a given weight to a given height in a given time, 1 foot-pound per minute of power being the amount of energy required to raise a weight of 1 pound to a height of 1 foot in 1 minute.

One horse-power equals 33,000 foot-pounds per minute.

POWER, LOSS OF.—Many and varied are the reasons for the falling off of power in an engine. Here the usual sources of this trouble are explained.

Loss of power in the engine may be brought about by a variety of causes, and sometimes by a combination of conditions tending towards the same end. Wear of the mechanism will naturally cause loss of power, but there are some misadjustments of a variety of kinds, which will cause the falling-off in the full power which the engine should develop. They may be classed, roughly, under five headings: Carburation, Ignition, Cooling, Valve-gear Timing.

Carburation.—With the modern carburettors there is very little to go wrong, and once they are fitted with jets of the correct size it is inadvisable to meddle with the jets except to see that they are not choked. A gradual reduction in the speed of the car, with the ignition and other matters normal, would indicate too little fuel getting to the engine. The main jet of the carburettor should be removed with the key provided and held up to the light to see that there was a clear way through. There is usually an additional jet and this also should be removed and cleared if there is obstruction. Water in the petrol may cause an obstruction which would not be seen, but if the filter is opened the gauge will show at once whether water has been passing. The float chamber of the carburettor should be opened and emptied and swilled out with clean petrol. Some carburettors have sliding valves, or "dash pots," which automatically adjust the air inlet (and the jet orifice in some cases) as the throttle is opened. These will drag if lubricated with too thick an oil, so upsetting the mixture. Sliding parts of the carburettor should not be oiled but should be clean and bright and may be cleaned best with petrol. If the carburettor floods when standing it may be due to a float needle which needs grinding on its seat. This can be done with rotten stone and oil. Possibly the float may be punctured also. If, when shaken there is a sound as of sand inside the float, then petrol has got in through a very small hole. To get it out immerse the float in warm water; bubbles will rise from the point where the tiny puncture is located. Keep the float immersed so long as the bubbles rise, then take it out, allow to cool (this is important), and then solder the tiny hole with the least possible speck of solder and filed clean.

See that the throttle opens fully with the accelerator pedal fully depressed and that the strangler comes fully open when released. Too much petrol and too little air, giving a rich mixture, will be indicated by a pungent, smoky exhaust. Too much air will be indicated by a falling off in power, spitting back and bad slow-running; it may be due to an obstruction in one of the jets, an air leak, or a choked filter which should be examined and cleaned.

Ignition.—Loss of power is caused if the ignition system is out of order. The sparking plugs should be clean and the gap at the points should be carefully adjusted with a plug gauge. The gap should be ·02 inch, if the engine has magneto ignition, and ·025 if it has coil and accumulator ignition. In a three-point plug all three gaps should be the same. The contact-breaker contact points should be clean and flat and should have a gap of ·018 inch when open. Loss of power will be caused if the gap is too close or too wide. All the ignition gear should be clean and dry. Timing of the ignition is set by the makers and should not be interfered with. Some contact-breakers on coil and accumulator systems have an automatic advance and retard by means of a centrifugal governor below the contact-breaker. This should only be lubricated very occasionally and with a very thin, light oil as used for clocks. Thick oil which gums up may result in very erratic action of the governor and so upset the automatic advance and retard action. A too retarded spark will cause overheating and great loss of power, while a too advanced ignition will cause knocking and roughness in running at anything but high speeds.

Cooling and Valves.—Loss of power will be experienced if the cooling system is not working efficiently, as for instance, when the fan-belt is slack and thus fails to drive the fan properly. A tensioning adjustment is provided to alter the centre distance of the belt pulleys to secure the correct tension for the belt. The radiator and the water-jacket of the engine should be emptied occasionally and filled up with hot soda solution and swilled out. Overheating may be due also to valves being carboned, pitted or not opening enough. The valves should lift their full amount and, taken as a general rule, the clearance between the valve-stem and the tappet (or the clearance at the rocker-arm in the case of overhead valves) should not be more than ·01 inch when the engine is hot. The valves should be clean on their face and on the seats—and must be ground in occasionally to ensure their closing properly.

Wrong Timing.—The valve and ignition timing of the engine cannot get out of adjustment unless the drive from the crankshaft to the camshaft has been misplaced, as regards the meshing of the teeth of the gear wheels—or the chain and the chain-wheels—which every method is employed. A wrong timing would cause serious loss of power, which would be experienced as soon as the car got running, but it will not come in ordinary usage, where only ordinary adjustments have been made.

Cylinder Wear.—A cause of loss of power which may become serious in extent is cylinder wear. When it occurs in a car which has covered a comparatively small mileage it is generally caused by using the strangler too much at starting and neglecting the proper lubrication of the engine. The former leads to wet petrol being drawn into the cylinders, and this washes away the oil from the walls, and the piston-rings then run dry against the cylinder and very rapid wear occurs. In early stages the trouble may be remedied by fitting new piston-rings, using a rather heavier oil and refraining from the use of the strangler. If the trouble is very pronounced, the remedy necessitates re-boring the cylinders and fitting new pistons—an expensive job, only to be undertaken by an expert and reliable firm.

POWER STROKE.—See *Ignition Stroke*.

PRE-IGNITION.—Term used to describe the ignition of the mixture within the cylinder before the completion of the compression stroke of the piston. Pre-ignition has a tendency to stop or reverse the engine, thus exerting considerable strain upon the piston, connecting-rod and bearings. It is due, usually, to too advanced timing of the ignition system.

PREMATURE IGNITION.—See *Pre-Ignition.*

PRE-SELECTOR GEARBOX.—A form of gearbox mechanism which enables the required gear-ratio to be " pre-selected " before it is actually brought into operation. A car travelling slowly, for instance, in first gear, may have its second gear " pre-selected " and then put into operation at a convenient moment by the simple depression of a pedal.

The use of a pre-selector gearbox obviates clumsy and noisy gear-changing, the operation of passing from low to high gears being carried out silently and sweetly. (See *Gears.*)

PRESSURE. — A squeezing or forcing effect. The phenomenon of gas pressure upon which all internal-combustion engines depend is due to the rapid state of motion of the constituent particles of the gas. These set up a ceaseless bombardment on the inner walls of the containing vessel (the engine cylinder) and it is the sum force of this bombardment which constitutes the *pressure* of the gas.

PRESSURE - FEED SUPPLY. — This expression usually denotes a system of supplying fuel from the rear tank of a car under pressure to the carburettor, the necessary small air pressure usually being provided by means of a pump worked off the engine.

PRIMARY.—The common abbreviation for electrical terms as, for instance, primary coil, primary winding, primary circuit, etc.

PRIMARY CELL. — A non-reversible cell for transforming chemical energy into an electric current. An ordinary dry battery is a typical example of a group of primary cells.

PRIMING PLUG.—A type of sparking plug through which petrol can be injected into the cylinder in order to facilitate quick starting of the engine in cold weather.

PRONY BRAKE.—Another name for a Dynamometer or horse-power testing device.

PROPELLER SHAFT.—A name given sometimes to the main steel shaft which transmits power from the engine assembly to the back axle of the car.

PULLEY.—A wheel having a depression or crown in its rim in which a belt, cord or rope runs, as, for instance, the fan, dynamo, or magneto pulley of an engine.

PUMP.—A device for forcing air or liquids from one place to another. It usually comprises a screw or a piston-like arrangement.

PUMP CIRCULATION. — Term usually describing the system of circulating the water around the cooling-jacket of an engine by means of a small water-pump driven off the engine. (See *Cooling Systems.*)

See *Thermo-syphon circulation.*

PUNCH.—Term applied to a variety of small steel tools, generally cylindrical in formation, which, being hit at one end by a light hammer, are used for the purpose of indenting materials, for driving wedges and other objects into position and for many other uses.

PUNCTURE-PROOF TUBE.—A type of inner tube for a pneumatic tyre the interior of which is coated with a plastic material. If any mechanical injury happens to the tube, the plastic material is forced into the cut by the air pressure within the tube, thus sealing up the damaged area.

PUSH RODS.—Long steel rods which operate overhead valves, being themselves actuated by revolving cams below.

Q

QUADRANT.—The fourth part of a circle. The name given to a similarly shaped piece of metal having teeth on its outer edge which is used in many steering and other mechanisms.

See *Steering Sector.*

QUARTER-ELLIPTIC SPRING.—Name given to a type of leaf-spring which, owing to its curvature and relatively short length, resembles a quarter of an ellipse.

QUICKSILVER.—See *Mercury.*

R

RADIATION.—The emission of energy in the form of light, heat, electrical energy, etc.

Used in conjunction with car technics, the term principally denotes the dispersal of the waste heat of the engine through the medium of its water-cooling system and *radiator.*

RADIATOR.—Literally, any device which gives off heat, light or other rays.

A car radiator is a heat-radiating apparatus comprising an arrangement of tubes and air-spaces at the front of the car. The hot water from the cooling-jackets of the engine circulates through the radiator tubes and is cooled down by the current of air passing between the tubes. (See *Cooling System.*)

See *Honeycomb Radiator, Gilled-tube Radiator.*

RADIATOR CAP.—The metal cap which screws down over the water-filling orifice of the radiator.

RADIATOR INDICATOR.—Term which usually denotes a special temperature-indicating device (not necessarily a true thermometer), usually fixed to the radiator cap and which indicates the approximate temperature-ranges of the radiator water.

RADIATOR LAMP.—Name usually given to a small heating-lamp constructed on the principle of the Davey Safety-lamp which is placed under the bonnet of a car in a cold garage in order to prevent freezing of the radiator water.

RADIATOR SHUTTER.—Name given to an arrangement of slats or vanes which are sometimes placed in front of the radiator of a car and which are controllable by the driver. Their object is to control the amount of air coming in contact with the radiator surface and thus to prevent too strong a cooling in cold weather.

RADIATOR THERMOMETER.—A special form of thermometer which is usually attached to the radiator cap of a car and which serves to register the temperature of the radiator water.

Special types of radiator thermometers may be connected with dials fixed to the instrument board of the car.

RADIUS.—The name given to a straight line drawn from the centre of a circle to any point of its circumference. The radius of a circle is therefore equal to half the diameter of the latter.

RADIUS ROD. — See *Distance Rod.*

RAKE.—Inclination or slope. The term is usually applied to the backs of car seats, or to the inclination of the steering column.

RAMP.—The name given to a mechanical, electrical or hydraulic device which is provided in many garages for the purpose of lifting cars bodily from the ground in order to permit of a clear space underneath them for inspection purposes. (See *Servicing Equipment.*)

RATCHET SPANNER.—A type of spanner the jaws of which when placed on the nut may be tightened or loosened by rotating the shank of the spanner in one direction or the other.

Ratchet spanners are useful in dealing with difficultly accessible nuts. (See *Spanners.*)

REAR AXLE.—See *Back Axle.*

REAR LIGHT.—The small lamp fitted at the back of a car which directs a white light on to the rear number-plate and projects a red warning light behind.

REAR-WHEEL SKID.—The condition of a car skidding on a road surface owing to its rear wheels sliding to the right or to the left.

RECTIFIER.—An electrical device which enables accumulators to be charged from an alternating-current supply. Usually comprises a special transformer or a rectifying valve which is connected up to the A.C. supply.

RED LEAD.—Chemical formula : Pb_4O_2. Lead tetroxide. A scarlet oxide of lead obtained by heating white lead in a furnace. It is used in the manufacture of battery plates. Mixed with greases or oils, red lead makes an effective packing for pipes, tubes, etc,, and as such it is often found in the busy workshop and garage.

Synonym : *Minium.*

RELAY.—Name given to an electro-magnetic device in which a current coming from a distance is caused to control a local electrical circuit. Relay - mechanisms designed for special experimental purposes are sometimes included in the electrical equipment of cars.

RESISTA.—A resistance alloy used for making resistance coils for electrical purposes.

It is a special form of manganese steel containing nickel, its average composition being Iron, 80 per cent ; Manganese, 5 per cent ; Nickel, 15 per cent.

RESISTANCE.—Electrical term used to denote the opposition of a body to the passage of a current through it. The standard of resistance is the *Ohm.*

RESISTANCE COIL.—A coil of insulated wire, usually of high resistance, which is introduced into an electric circuit in order to control or moderate the current flowing through the circuit.

Resistance coils, or " shunts," are contained in many electrical measuring instruments, ammeters, etc.

RESISTANCE WIRE.—Wire produced from special alloys (" Resistance Alloys ") which have a high electrical resistance. Used for the making of rheostats, resistance coils, etc.

See *German Silver, Manganin, Rheostene*, etc.

RETARDATION.—See *Acceleration.*

RETARDED IGNITION.—Term used to denote the setting of the ignition-timing of the engine, so that the spark occurs at the plug points after the piston has reached the top of its stroke and has begun again its downward journey.

Synonym : *Late Ignition.*

RETENTIVITY.—The capability of a metal for retaining its magnetism, Used in connection with the iron cores of coils, solenoids, and other electro-magnetic instruments.

RETREADING.—The process of replacing a worn tread on the outer cover of a tyre by a new one. The operation is essentially one of vulcanisation or rubber-welding. (See *Tyres.*)

REVERSED CONE CLUTCH.—A modification of the ordinary cone clutch in which the inner cone is drawn away from the engine in order to effect its engagement. It is sometimes known as the "Internal" clutch.

REVERSING GEAR.—The gear-train which enables the motion of the car to be reversed. This reversal is usually effected in one or two ways: (1) by an extra gear wheel which is meshed with two other wheels; (2) by two bevel gears engaging with a bevel driving wheel.

A few petrol engines which actually reverse themselves have been invented, but, owing to their complications, they were never successful.

REVOLUTION INDICATOR.—An instrument for registering the number of revolutions per minute of a wheel or shaft. They work on principles similar to those of an ordinary speedometer.

Engine-revolution indicators are sometimes attached to the instrument-boards of cars.

RHEOSTAN. — A resistance alloy containing copper, manganese, nickel, cobalt and zinc. Used for the making of resistance wires.

RHEOSTAT.—The name given to any type of variable resistance included in an electrical circuit for the purpose of varying the current-flow therein. Rheostats of different patterns are included in many electrical gadgets intended for car use.

The name was first coined by Sir Charles Wheatstone, the eminent electrician of the last century, who derived it from the Greek words, *Rhein*, to flow; *statos*, standing.

RHEOSTENE.—A nickel-steel alloy used for the manufacture of electrical shunts and resistance coils. At 0° Centigrade, its conductivity is 1·9, the conductivity of silver being regarded as 100.

RIBBON RADIATOR.—A form of car radiator comprising a system of corrugated members or sheets which form between them a series of vertical tubes of twisted, ribbon-like shape. Owing to its "flatness" of construction, this type of cooling device is sometimes known as the "film" radiator.

Due to their corrugated formation, ribbon radiators are constructionally very strong. There is very little soldering in them and their cost of construction is relatively low.

RICH MIXTURE.—An expression referring to the relative proportions of fuel vapour and air in the explosive mixture within the cylinder, the "richness" of the mixture being determined by the current of fuel vapour present.

An "over-rich" mixture is, of course, one in which too great a proportion of fuel vapour is present, there not being sufficient air to completely combust it.

RIM.—A raised edge, margin or brim. The outer edge of a road-wheel which carries the tyre on the wheel.

Wheel rims are made detachable or non-detachable.

RING JOINT.—A type of Universal joint consisting essentially of two ring systems at the end of the shafts bolted together.

RIVET.—Name applied to a metal bolt which is passed through two pieces of material and then secured tightly in place by hammering flat at both ends.

Many clutch-lining materials are attached to their metal discs or plates by means of rivets.

ROAD RESISTANCE.—The resistance which a road surface offers to the rolling movement of vehicles along it. It varies with the foundations of the road, its surfacing, the prevailing temperature, the speed of the vehicle and the nature of the tyres fitted to it.

Road resistances, although well-known to cyclists, are not very noticeable in the case of cars, although they are capable of influencing considerably the petrol consumption of a motor vehicle.

ROCKER. — A pivoted lever having a rocking motion by means of which it conveys movement from one point to another. Used in valve mechanisms.

See *Cam Rocker*.

ROLLER BEARING.—A bearing which comprises a set of tempered steel rollers arranged in a cylindrical metal casing. Each roller is free to revolve in its setting. When a shaft revolves in this bearing it makes contact with each roller and they rotate with it.

ROTARY VALVE.—A special form of valve which is driven off the camshaft by means of a spiral screw. It is usually mounted in the normal side-valve position and by its operation it establishes communication successively between the cylinder and the induction pipe and the cylinder and the exhaust pipe.

Like the slide valve, the rotary valve is practically silent in operation. (See *Valves*.)

R.P.M.—The recognised abbreviation for "Revolution per Minute." The rotating speed of many revolving mechanical parts is customarily measured in "revs. per minute."

RUBBER. — India-rubber, or caoutchouc, is the coagulated sap of certain trees growing in tropical districts. In its natural state, rubber is white, but it becomes black by curing.

The rubber of motor commerce is nearly always material which has been vulcanised, or sulphur-treated, in varying degrees. The vulcanisation process renders the rubber hard and more enduring, yet it preserves its elasticity.

Rubber is, of course, an excellent electrical insulator, and for this purpose it has a large use in the electrical world as well as in the motor industry.

RUBBER SOLUTION.—See *India-rubber Solution*.

RUHMKORFF COIL.—See *Coil*.

RUNNING BOARD.—Name given to the narrow platform or "board" which extends along each side of the car thus providing a convenient step for the driver and passengers to enter and leave the vehicle.

RUNNING GEAR.—Term sometimes applied to the under-frame of a car with its assembly of road wheels, axles, etc., but not including the engine or its parts.

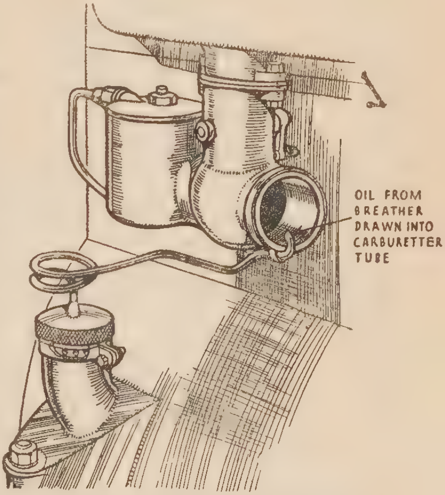

OIL FROM BREATHER DRAWN INTO CARBURETTER TUBE

FIG. 290.—This sketch shows a system of upper cylinder lubrication in which use is made of the oily vapour blown out by the crankcase breather. A useful device when running-in a new car (*see* page 256).

RUNNING-IN A NEW CAR.—Patience and restraint are necessary in running-in a new car if the job is to be done thoroughly, but the time spent is a very small proportion of the running hours that will be totalled up, before the car is passed on to the next owner.

The parts of a modern car are made very accurately, some of them to very fine limits. Even so there are many moving parts which have little " high spots " on them, however careful the maker may be. The fact that no two moving parts of a car touch one another, may seem a ridiculous statement to the new owner. Each part is protected by a film of oil and it is this film which separates the two surfaces. The little " high spots " present on the cylinder walls, the teeth of the pinions and other working surfaces, tend to break down this oil film and, consequently, friction and heat are created.

When running-in an engine we are really gently grinding away these high spots and, when the process is completed, every working part should have a mirror-like, dead smooth surface. Don't get the idea from this description, that the cylinder walls of a new car are covered with miniature mole hills. It would almost be impossible to measure the " high spots," but they are there just the same, and must be removed if the car is to operate at maximum efficiency.

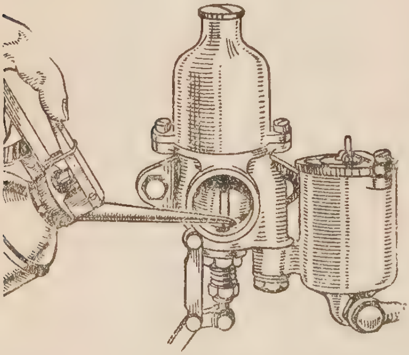


FIG. 291.—A few drops of oil injected into the carburettor intake while the engine is running will cure dry and sticking valve stems. Upper cylinder lubricants which prevent this trouble are obtainable in various brands.

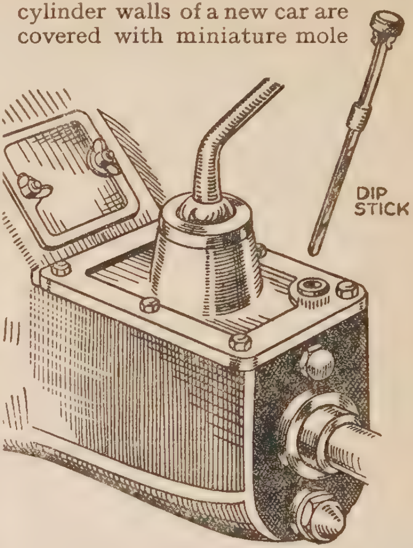


FIG. 292.—On up-to-date cars a dip-stick replaces the plug, previously referred to, for checking the gearbox oil level. This should be removed, wiped, replaced and inspected.

In recent years the old theories, which governed running-in, have been completely exploded. The old idea was that the car should never exceed something like twenty miles an hour for the first 1,000 miles. After this period the engine and gears were considered to be in the best possible condition and the car ready for any kind of work. It has recently been suggested that these ideas are a fallacy. The slow running of the engine only effects the high parts very gradually and probably six or seven thousand miles would be required properly to run in an engine by this method.

Do not Stress the Engine.—With this running-in process, the speedometer is practically ignored. There is no supposed danger spot above twenty or thirty miles an hour and the work that the car does is immaterial. The main precaution is to see that the engine is never stressed. The accelerator should never be depressed enough to make the engine really " bite," whether climbing a hill or getting away on the green signal. With a small throttle opening, the engine may drive the car without effort up to forty or more miles per hour over a distance on the flat or a slight down grade. Only good can come of this speed so long as the engine is not allowed to overheat. When climbing a hill, change down very early and climb it in bottom if necessary, always keeping the engine running at an easy speed. When getting away from a standing start be careful not to " rev " the engine. Go through the gears with a small throttle opening and pick up the drive, after each upward change, without calling upon the engine for any appreciable effort. Develop, for the running-in period, a " plenty of time and all day to do it in " sort of attitude. A properly lubricated engine, and when it is new, should not seize up in the early stages, though this has been known to happen. Should this occur, the engine should be allowed thoroughly to cool off. Remove the sparking plugs and inject a little engine oil into each cylinder. This will probably oil up the plugs when the engine is started again, but it is a wise precaution. When it has cooled down, set the engine to run at about 400 revs per minute—a little faster than the slow running speed—and, with an oil can, drop small quantities of oil into the air inlet of the carburettor. About one and a half minutes of this process will suffice, the object of it being, thoroughly to lubricate the cylinder bores above the piston rings.

It has been pointed out that the object of rubbing down the high spots, is to prevent them breaking the oil film. It is equally important that this film should be as " oily " and tenacious as possible. The engine and gear oil recommended by the makers of the car should be used, and to this should be added some colloidal graphite running-in compound which can be purchased at most garages. Graphite, though a solid substance, an excellent lubricant. When used in conjunction with the engine and gear oils it deposits a film over all the working surfaces, making them, to a certain extent, self-lubricating.

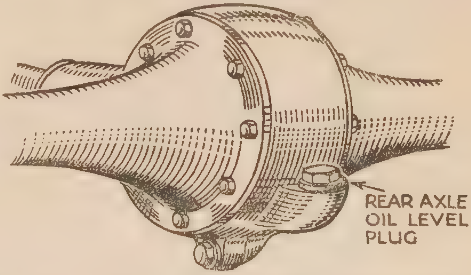


FIG. 293.—The level plug in the rear axle should receive attention.

It is wise to provide some kind of lubrication for the upper cylinder walls, and here again colloidal graphite is helpful. There is a special type which should be mixed with the petrol and is thus carried into the cylinder head with each charge of petrol mixture. Further, as the mixture and the spent gases have to pass the inlet and exhaust valves, the graphite lubricates the valve stems and prevents them sticking.

During the running-in process the engine oil should be changed at 300, 750 and 1,250 miles. The gearbox and rear axle should be drained and flushed with paraffin at 300 miles. These oil changes are necessary as, during the early running of a new car, small particles of metal become detached and it is necessary to remove them, if damage is to be prevented. Be careful only to fill the gearbox and rear axle to the level of the plug provided. Too much oil in the gearbox will prevent an easy gear change and if the level in the rear axle casing is too high, the oil will find its way on to the brake linings. Always keep the oil level in the sump, up to the "Full" mark on the indicator. More than this is not an advantage, as the surplus will only be blown out of the exhaust pipe.

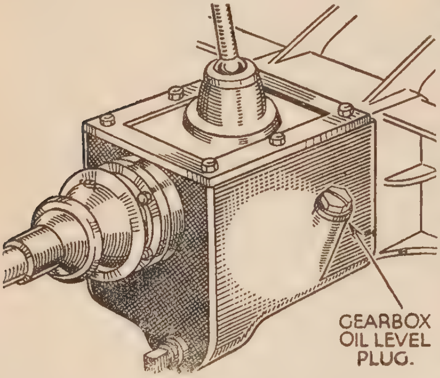


Fig. 294.—Check the level of the gear-box oil by removing the plug located at the side.

Having completed the first thousand miles of this running-in process, do not imagine that the car is ready to be driven to maximum capacity. Speed and demand on the engine should be gradually increased until the day is reached, probably after a few thousand miles have been run, when real performance can be tested, and maximum speed indulged in without fear of damage.

S

SAFETY-GAP.—The small gap which is arranged in the high-tension circuit of a magneto in order to eliminate the possibility of strain on the armature windings when the magneto is run without a closed circuit. This spark gap is usually of the order of 5 or 6 millimetres.

SAFETY-GLASS.—A special kind of glass manufactured by cementing a sheet of celluloid between two sheets of glass. When broken, the glass holds together and does not splinter or fly apart. Glass of this type is much used for car windscreens, etc.

SALOON.—Name usually given to the spacious all-enclosed bodywork of a car seating at least four people.

SALOON-LANDAULET.—A name which describes the glass-enclosed bodywork of a car which is provided at the rear with a hood capable of being raised and thrown back. A combination of the saloon and landaulet bodyworks.

SANDPAPER.—See *Glasspaper*.

SCAVENGING.—Term used to describe the clearing out of the products of combustion from the cylinder during the exhaust stroke of the piston. In some engines, special devices are fitted to effect the maximum degree of scavenging.

SCLEROMETER. — An instrument used in engineering works for the testing of the hardness of metal (particularly steel) objects.

From the Greek: *Skleros*, hard.

SCORE.—Term used to denote a deep scratch, groove or other marking made in the interior wall of the cylinder through which gas leakages may take place.

SCREW CUTTING.—A mechanical process of forming a thread on or within a cylindrical shaft. The term is usually restricted to screw threads which are manufactured by means of lathes.

SCREW PIN.—An ordinary screw which is used to secure a piece to the end of a shaft or in circumstances in which it is not convenient to drill a hole right through a given part. Used frequently in repair work.

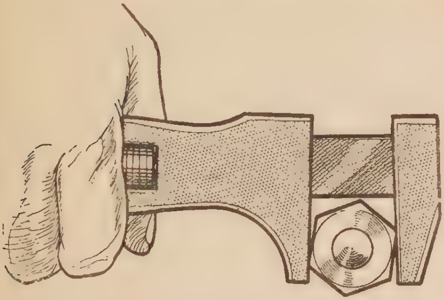


FIG. 295.—An Adjustable Spanner, often referred to as a screw wrench. Misuse causes the jaws to lose alignment.

SCREW WRENCH.—A large adjustable spanner used for heavy work. It is also known as a "Monkey Wrench."

SEAT RAILS.—The metal rails secured to the floor of the car in which the sliding seats move.

SECONDARY SPRINGS. — See *Auxiliary Springs*.

SEGMENT.—A name applied to the individual metal strips or portions of the commutators of dynamos and similar machines. Each commutator segment is connected to one or more armature wires and insulated from the two adjacent segments.

SEIZING.—The act of two rubbing surfaces binding together owing to the frictional heat generated having locally melted the parts and caused them to become welded together.

Applied to motoring technics, the term is in general, used to denote any binding tendency—great or small—of the piston in the cylinder due to the above-mentioned cause.

The term is also applied to similar phenomena occurring at the surfaces of bearings, etc.

Seizing, when it occurs, is nearly always due entirely to inadequate lubrication.

SELF - STARTER. — The device by means of which a car engine is started. Usually, it comprises a small but powerful electric motor working off the car battery. The electric motor, by means of suitable gearing, operates the flywheel of the engine. Immediately the engine starts, an automatic device is put into action whereby the motor is disconnected from the revolving shaft.

See also *Starter*.

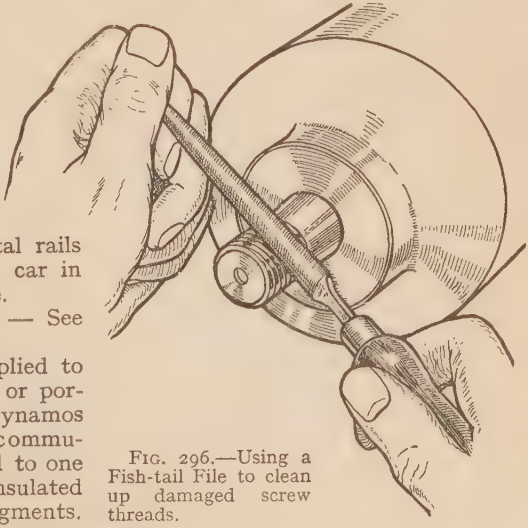


FIG. 296.—Using a Fish-tail File to clean up damaged screw threads.

SELF-STARTER DEFECTS.—In the days before motor cars were fitted with electric engine starter the motorist found that if his engine was not in tip-top condition as regards carburation, ignition and lubrication the starting was a laborious and sometimes a lengthy operation. When he found this so, he took the obvious course of attending to his adjustments so that the drudgery of starting was reduced. He knew more about his engine then because these minor defects were forcibly impressed upon him. But with the starter at hand he now presses the button and the poor starter and dynamo often have to take the load and strain of starting under unfair and adverse conditions. This means an enormous and very damaging electrical strain on the starter windings and on the plates of the accumulator. For unless the starter can start at once when the electrical circuit is closed by the application of the switch there comes what is practically a dead short on the battery; such shorts tend to buckle the plates and loosen the lead oxide with which they are pasted, and this means that the oxide falls to the bottom of the case and reduces the electrical efficiency of the battery. The buckling may be severe enough to cause a short in the battery itself. A good and expensive battery may thus quickly be ruined.

The Starter.—Similarly, the windings of the starter are subjected to very great electrical pressure from the battery and, since the armature cannot rotate (due to the unfair load being too heavy) the coil windings heat up, and a burning of the insulation may take place resulting in an expensive repair entailing the rewinding of the armature. The starter seldom gets the attention it deserves. It should be examined occasionally to see that the carbon brushes on the commutator are bedding down properly and that the commutator is clean, free from oil and has all its segments sharply defined and with clean and smooth surfaces to the copper segments. The commutator can be cleaned with a strip of fine glasspaper of its own width pulled around it. Do not use emery paper or emery cloth. The carbon brushes which pick up the current from the commutator should bed down to the natural curve of the latter and should be clean and black and not glazed. The springs which hold the carbon brushes in contact with the commutator must be strong enough to make sure and certain contact between carbon and commutator. Over oiling may cause carbon deposit on the commutator which will negative the clean cut slots. The oil becomes carbonised by the heat of the sparking which should be non-existent. There is an adjustment provided for what is called the " third brush " but this should never be interfered with. It is set by the makers after most careful tests and should be left as they have set it.

The Pinion.—The self-engaging pinion, known as the " Bendix drive " which meshes with the teeth on the engine flywheel rim is often responsible for the non-functions of the starter. When the starter armature begins to rotate, it runs up on a quick thread on the spindle of the armature and instantly engages with the teeth on the flywheel. If it has been over lubricated with the thick oil which has gummed up it will drag. It may even not go along the shaft at all, for it travels only by its own inertia. In any case it delays the engagement and allows the

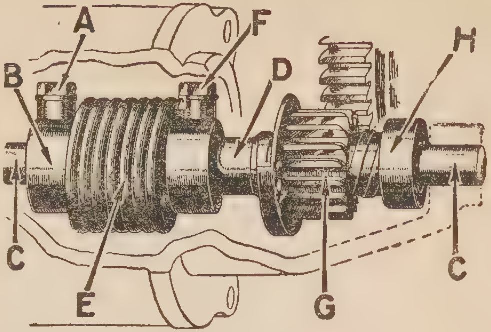


FIG. 297.—The starter motor pinion. (A) spring bolt, (B) spring collar, (C) shaft, (D) screwed sleeve, (E) torsion spring, (F) spring setscrew, (G) pinion, (H) collar on sleeve.

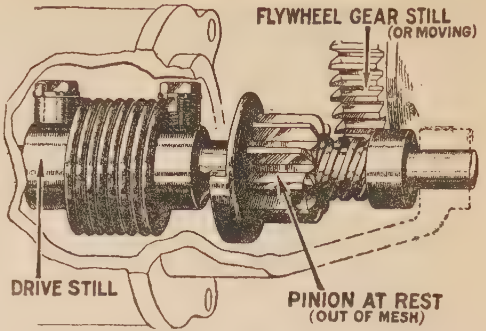

FLYWHEEL GEAR STILL
(OR MOVING)
DRIVE STILL
PINION AT REST
(OUT OF MESH)

FIG. 298.—The starter motor pinion. This diagram shows the starting motor at rest with the pinion out of mesh.

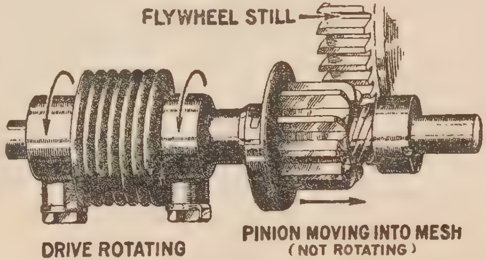

FLYWHEEL STILL
DRIVE ROTATING
PINION MOVING INTO MESH
(NOT ROTATING)

FIG. 299.—The starter motor pinion. This shows the motor shaft beginning to revolve. The inertia of the pinion causes it to move outwards along the spindle as shown above.

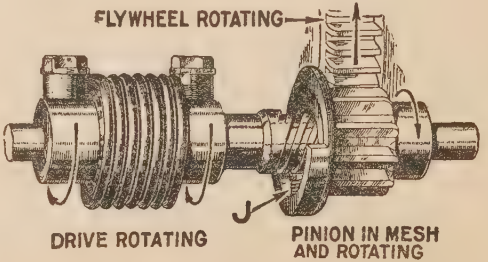
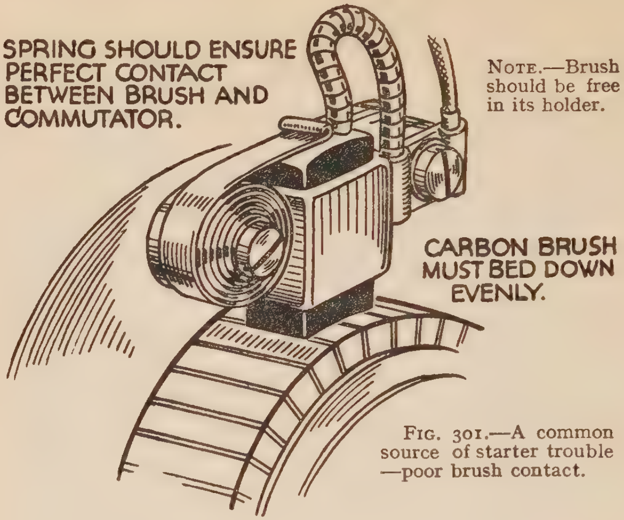

FLYWHEEL ROTATING
J
DRIVE ROTATING
PINION IN MESH
AND ROTATING

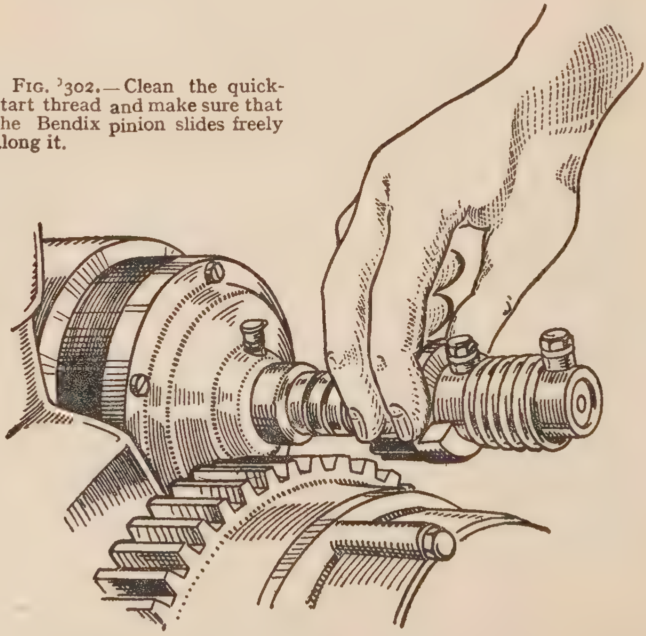
FIG. 300.—This sketch shows how the motor pinion is returned along the shaft when the engine starts.


SPRING SHOULD ENSURE PERFECT CONTACT BETWEEN BRUSH AND COMMUTATOR.
CARBON BRUSH MUST BED DOWN EVENLY.

Note.—Brush should be free in its holder.

Fig. 301.—A common source of starter trouble —poor brush contact.

Fig. 302.—Clean the quick-start thread and make sure that the Bendix pinion slides freely along it.



starter armature to attain so high a speed that engagement is impossible and a heavy load is put on the winding of the armature and on the plates of the battery. Where the self-engaging pinion is exposed (in some cases it is inside the flywheel and clutch housing) it is liable to get dust and dirt on the oil with which it is lubricated and this prevents its rapid automatic action. In such cases it is inadvisable to use a liquid lubricant. The pinion, and the quick thread upon which it moves, should be swilled with petrol so as to remove all oil, and allowed to dry. When it is thoroughly dry it should be dusted with the finest plumbago powder well brushed into the quick threads of the spindle with a camel hair "mop" brush and the pinion should be moved along and around by the fingers to ensure that the black lead has penetrated between thread and pinion. Such treatment will render a sticking pinion impossible and will avoid all the troubles we have outlined.

Avoid Heavy Load.—Heavy loads on the starter and the battery should be avoided. This is best done by keeping ignition adjustment in order. The correct gap at the contact breaker and at plugs. Clean plugs, clean contact breaker, good clean contacts of all wires are essential. A loose contact in any of these connections will reduce the power of the starter. They should be occasionally cleaned and tightened thoroughly with a good surface of metal in contact. This last is of great importance. The avoidance of heavy load is the greatest point about keeping the starter installation in good condition. In cold weather the oil in the engine and gear-box offers a great resistance to turning the engine and is the cause of most starter and battery strain. It is, therefore, a good plan to ease the initial stiffness caused by the lubricant by turning the engine by hand. Swing the engine round a few times with the ignition off. The starter can then "take over" and will (other things being in good order) give instant starts with least electrical strain on battery or starter motor.

The Charging.—The charging-up of the accumulator is as important in connection with starting as it is with lighting and ignition, and is dealt with where these matters are under consideration. But since the starting load is heavy the car owner who uses his car for many calls with many starts, or who does a lot of night driving may find his current supply in the battery being depleted. The ampere-meter on the dash shows the charging rate, and if it keeps well over to the full charge position it may be taken that all is in order provided the electrolyte in the battery covers the plates and is of correct strength. Avoid too much starting at night when all lights are on. It puts a big drain on the accumulator. If lights go dim when the starter is operated the battery is having a bad time and should be relieved of the starter load as much as possible. The ampere-meter will show whether the battery is getting charging current when all lights are on. It should do so, and if the contrary is found, the dynamo or battery should receive attention without delay.

SELLER'S THREADS. — See *American Threads.*

SEMI-FLOATING AXLE. — A type of back axle construction in which the total rear weight of the car is borne by the axle-shafts of the rear wheels which have to revolve at the same time.

SERVICING EQUIPMENT.—The high efficiency and dependable performance demanded by users of the modern car have hastened the development of the service station quite as much as the improvement in design of the vehicle itself. Gone are the days when the motorist who had neither the time nor the inclination to " condition " his own car, was deprived of its use for a whole week whilst it remained in dock for an overdue greasing and decarbonising.

The up-to-date service garage has been driven neck-and-neck with the car designers along the race-track of post-war ideas, and has been obliged to adopt a system of quick servicing very similar to the progressive production methods used by the manufacturer. A special power-driven appliance for each job is now installed throughout the length of the really modern service station, cleaning, checking, testing, and adjusting every vulnerable point in systematic order, so that a mud-caked, oil-starved car entering at one door leaves, within a few hours, at the other in a perfect mechanical condition. Compressed air is the chief source of power used to eliminate slow hand labour, and to achieve the remarkable speed and thoroughness with which the jobs are done.

A clean exterior is the first essential. The car is driven on to a powerful hydraulic lift and is given a high-pressure bath. The caked mud and grease comes away easily under the penetrating jet of water so completely that fractures, loose nuts and slack joints are immediately detected.

Next in importance to a clean exterior is a clean " inside." No longer does the mechanic have to carry out a messy job, fumbling in a dark, oily pit, seeking the drain plugs of the oil sumps. The modern service engineer wheels the drain tank beneath the car. and raises a telescopic funnel to the sump. Centrally arranged within the funnel are a series of socket spanners mounted on a multiple head. The correct spanner is rotated into position, and a threaded spindle protruding from the side is turned, unscrewing the plug and releasing the oil. Little opportunity here for dust or grit to enter the casing !

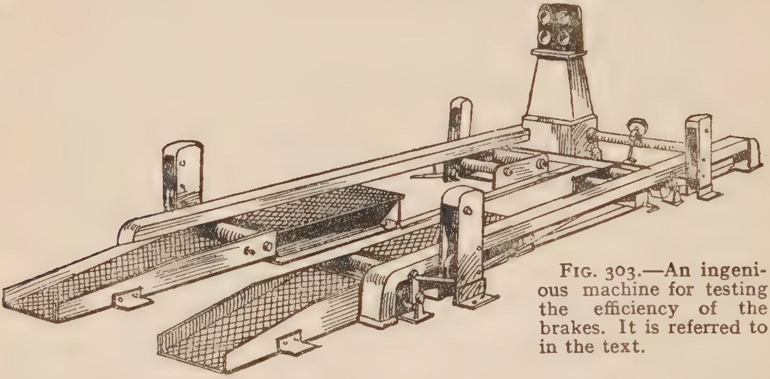


FIG. 303.—An ingenious machine for testing the efficiency of the brakes. It is referred to in the text.

Rapidity and Cleanliness.—Flushing out the emptied sump is a matter of minutes with the aid of the modern air-flusher. This device seeks out the dirty lubricant and, at the turn of a lever, injects paraffin, which it agitates in the casing and scours it clean.

Now, the service engineer has a clean car upon which to work, and whilst it remains poised above him, he applies the pressure lubricator. As much as 5,000-lb. pressure is used for the "first shot" to ensure that the grease reaches all vital points. This is followed by a spray lubrication from a pistol-grip nozzle to inject oil into all joints, spring leaves, etc., where rust may have formed. This special lubricant penetrates and creeps right to the core of all moving parts, covering them with a protective film of oil.

The car can now descend, as the road wheels are necessary to the remaining jobs. While these operations are being carried out, the sumps are refilled, the engine inspected for tappet clearances and the ignition coil, starter, plugs, dynamo and lamps tested with another uncanny measuring instrument. Insulation and efficiency are checked.

Brake testing and balancing is a highly scientific job and, in these days of rapid acceleration and braking, are most important.

There is a definite relationship between the weight of a car, the speed of travel, the retarding force exerted by the brakes and the distance required to stop it. Given any one of these three factors, the fourth can also be found.

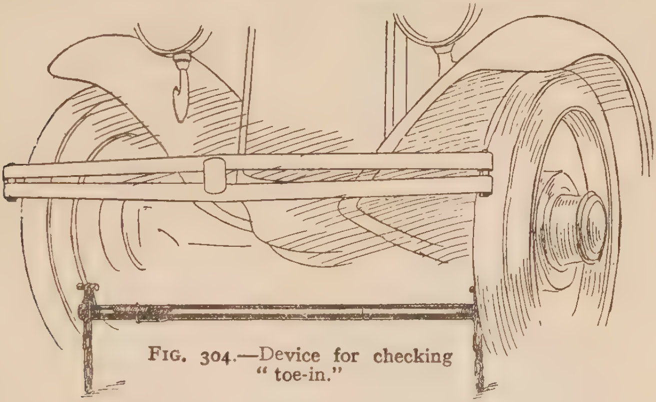


FIG. 304.—Device for checking "toe-in."

Brakes are graded by ascertaining the "braking" force in pounds of road-pull on each wheel.

The method employed by the up-to-date service garage is amazingly quick and accurate. The car wheels are driven on to four platforms fitted with rollers which are designed to reproduce the conditions of a good, dry road surface.

In the electrically-operated machine, the relative power of the brakes at any given pedal pressure is shown on the indicator dial. If the brake-drum is oval, its degree of ovality is shown. A worn lining or greasy band is indicated by the needle refusing to balance with the corresponding needle of the other brake. A final reading shows in how many feet the car can be brought to a standstill at any given speed. It is obviously a simple matter to adjust the brakes to a fine degree of efficiency in a few minutes.

Checking Alignment.—Wheel adjustment is next checked for correct "toe-in." The gauge is placed between the tyres at the correct height from the ground. The pointer is set at zero, the car moved forward until the gauge reaches a corresponding position at the rear of the wheels, when the exact amount of "toe-in" is recorded and adjusted.

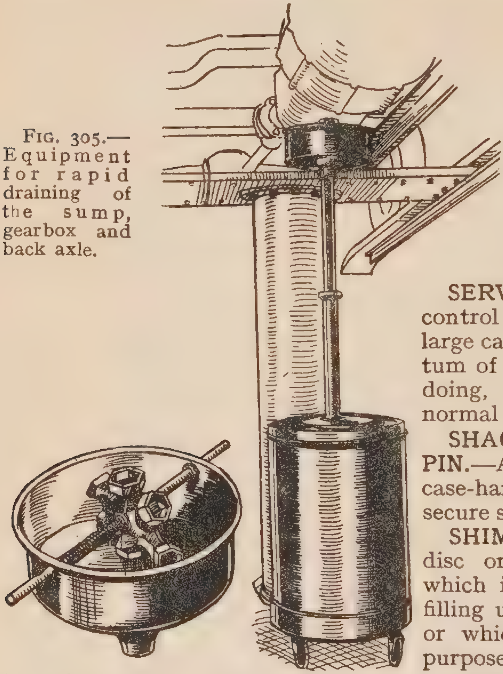


FIG. 305.—Equipment for rapid draining of the sump, gearbox and back axle.

Camber testing is important to avoid wheel wobble, and difficulty in cornering. A special gauge is set and the steering swung over to full lock. An arc is thereby described on the plate of the gauge and pointers record the castor angle and camber angle.

All that remains now is to check and inflate tyres to the correct pressure and refuel.

There are many other speedy methods used in the overhaul of the car that do not come strictly within the term "servicing," such as power grinding and refacing of valves, reboring cylinders, decoking, etc. All of which contribute towards the elimination of road trouble by anticipating failure with scientific diagnosis.

SERVO-MOTOR. — A brake-control mechanism fitted to some large cars which utilises the momentum of the moving car and, by so doing, increases the power of the normal braking of the car.

SHACKLE-BOLT: SHACKLE-PIN.—A steel bolt or pin, generally case-hardened, which serves to secure spring shackles together.

SHIM.—Name given to a thin disc or plate, usually of metal, which is employed as a means of filling up a space created by wear, or which is used for some other purpose of adjustment.

SHIMMY.—A term which is used to describe a species of rapid side to side vibrations of the car wheels which occur at fairly high road speeds and which are transmitted through the steering mechanism to the hands of the driver. (See *Steering*.)

SHOCK-ABSORBERS. — Name given to many varying devices which generally incorporate some arrangement of coiled springs. They are fitted to the car for the purpose of absorbing heavy road shocks. Usually, they are attached to the car frame and they act by controlling and subduing the movements of the leaf springs. (See *Springs*.)

SHORT CIRCUIT.—The creation of a bye-path for the flow of an electric current, due to the breakdown of an insulator or to some other cause, the current flowing across this path in preference to proceeding along its appointed circuit. Short circuits form the basis of many electrical troubles.

SHUNT.—See *Resistance Coil*.

SIDE LAMPS.—The name given to small auxiliary headlamps mounted on the front side-wings of a car.

SIDE SLIP.—A form of skidding. The slipping away of one or more of the road-wheels of a car from the line of its motion. It may be caused by sudden braking on a greasy road surface, by taking a corner too sharply, and by several other factors. Present-day cars, however, are designed to combat and minimise this possibility.

SIDE-VALVE.—Term somewhat loosely applied to any type of valve which is set in the side of the engine.

SIDEWINGS.—See *Wings*.

SILENCER.—A device fitted to the exhaust system of an engine whereby the pressure of the exhaust gases from the engine is considerably reduced before they reach the outer air. By this means the noise of the escaping gases is practically eliminated.

Silencers generally comprise some form of expansion chamber for the exhaust gases in which they can dissipate a good deal of their energy before gaining access to the external air.

SINGLE-ACTING.—A term applied to the piston in the cylinder of an internal-combustion engine on account of the fact that the power-thrust is generated on one side of it only.

The piston of a steam engine is " double-acting," for steam pressure can be applied to both sides of it.

SINGLE-POLE SYSTEM.—Term usually denoting the electric wiring system of a car in which the return circuit to the battery is provided by the metal frame of the car, one of the electrodes of the battery being permanently attached to some part of the car frame.

This type of car wiring makes for simplicity and economy of wire.

See *Double-pole system*.

SIX-STROKE CYCLE.—Name applying to an internal-combustion cycle of operations in which six piston strokes were utilised to form the sequence of operations. The system was not practicable, and is not now in use.

SKIRT.—See *Piston skirt*.

" SLACK." — Applied to the steering-wheel control of a car, this term denotes the extent to which the steering-wheel can be turned without affecting the road-wheels.

SLAP.—See *Piston slap*.

SLIDING JOINT.—A form of universal joint in which two small metal blocks mounted on the end of the one shaft engage in corresponding slots formed in the end of the opposite shaft, a sliding movement of the blocks in the slots being provided for.

See *Universal joint*.

SLIDE VALVE.—A type of engine valve, originated by the Daimler Company, in which the entry and exit of the cylinder gases is controlled by two concentric sliding sleeves placed between the piston and the cylinder, and which, by sliding up and down, open and close the valve-ports in correct sequence.

Slide valves are very silent in operation when working correctly.

SMALL END.—See *Little end*.

SOAPSTONE.—See *Steatite*.

SOLAR OIL.—A name sometimes given to a portion of the

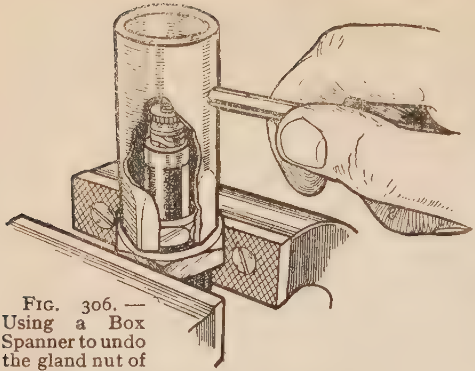


FIG. 306.—Using a Box Spanner to undo the gland nut of a sparking plug while the body is held in the vice.

heavier oil resulting from the fractional distillation of crude petroleum.

SOLDER.—Generic name used to designate a number of fusible alloys

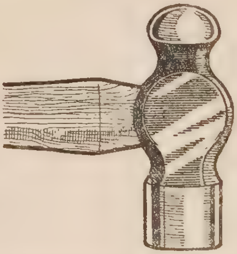


FIG. 307.—A useful type of Hammer is the ball paned type.

which are conveniently employed for joining metals together.

"Common solder," as used for electrical work, usually contains one part of lead to one part of tin, although different solders exist which are composed of lead alloyed with tin, the proportions of the latter varying from 30 to 70 per cent.

SOLENOID.—Name given to an arrangement comprising an iron or steel bar which is free to move within a coil of wire carrying a current, the bar being attracted or repulsed by the coil according to the direction in which the current is flowing.

Solenoids enter into the construction of many electrical instruments, among them being electrical gear-changing mechanisms.

SOLID TYRE.—A cover or band of hard rubber (or other material) which is secured in direct contact with the rim of the road-wheel without any intervening air space. Used largely for heavy motor vehicles.

SPANNER.—An implement used for obtaining a firm grasp on a nut for the purpose of its manipulation.

Spanners are of many various types and patterns.

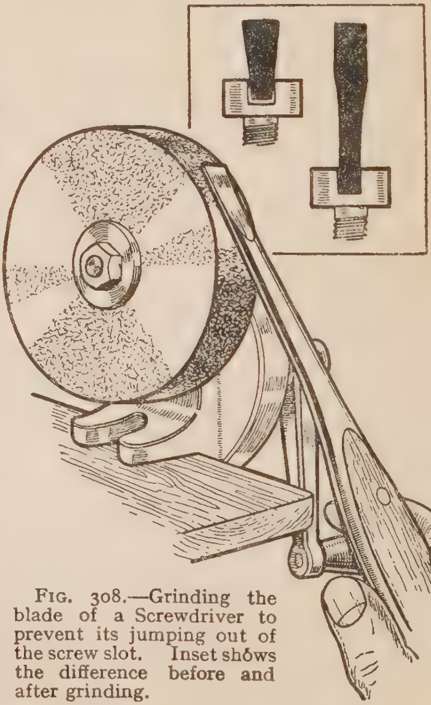


FIG. 308.—Grinding the blade of a Screwdriver to prevent its jumping out of the screw slot. Inset shows the difference before and after grinding.

SPANNERS, PLIERS, AND SCREWDRIVERS.—On the motor car the $\frac{1}{4}$ inch by $\frac{5}{16}$ inch double-ended spanner fits the majority of nuts—that is if the car is English. The jaws of double-ended spanners are offset for a purpose. The offset enables the spanner to be used in confined spaces by turning the nut as far as possible and then turning the spanner over, thus putting the handle in a different position.

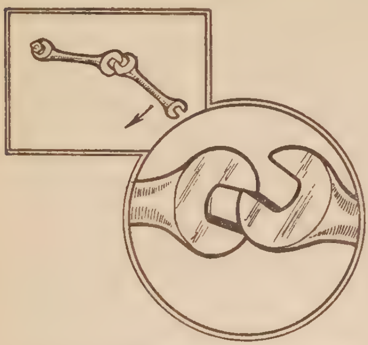


FIG. 309.—Locking two jaws increases purchase.

A spanner should always be the correct size for the nut to be turned. If it is too large through wear it should be discarded, as it will damage the faces of the nut and perhaps make it impossible to remove. The nut should not be turned with the tip of the jaws or the spanner will be sprung. Always place the spanner fully home and see that the force is applied to the base and not the top of the nut. A clean spanner will not slip like an oily one, which also gives a slippery hold for the hand.

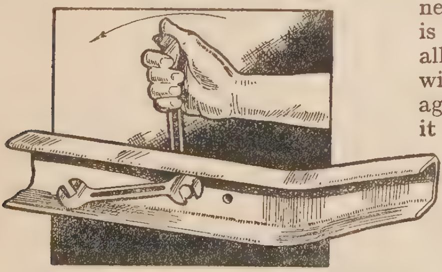


FIG. 310.—Allow the spanner to turn until it comes up against some part of the car.

In order to get more purchase on a spanner for a hard nut, a piece of pipe can be slipped over the end. By interlocking the jaws, increased power can also be exerted, though this method should only be used with robust tools. It sometimes occurs that a spanner is not long enough to reach a particular nut and here also the interlocking method is useful. Where it is necessary to hold a bolt while a nut is tightened, it is usually easier to allow the inside spanner to turn with the bolt head until it comes up against some part of the car where it is held stationary. More force can then be applied to the nut.

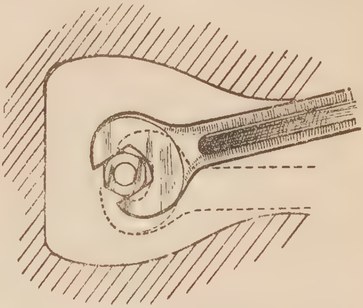


FIG. 311.—Off-set jaws enable the spanner to be used in a confined space.

A jerk will often "start" a tight nut where steady pressure will not be enough. Bolts screwed into aluminium and other soft metals should not be tightened with great force or the threads will be stripped. Never use a large

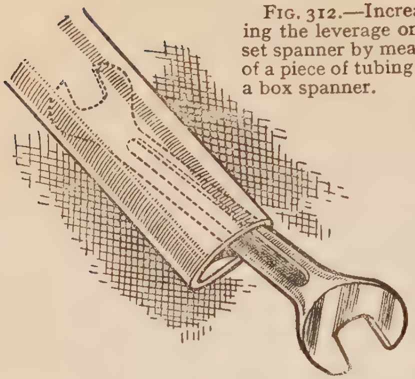


FIG. 312.—Increasing the leverage on a set spanner by means of a piece of tubing or a box spanner.

spanner in these cases as the power applied on the end of a long handle is very great.

Adjustable Spanners.—There are a number of well-known adjustable spanners on the market. Make it a firm rule never to use an adjustable spanner unless absolutely necessary. Never use an adjustable spanner with the jaws wide open or they will be sprung and the spanner will become useless. There is a right and a wrong method of using a spanner of this type. In placing the spanner on the nut, the jaws should always point in the direction in which pressure is being exerted. If fitted to the nut in the opposite way the spanner will be damaged and the grip will be weakened. An adjustable spanner should never be used with the jaws "end-on" to the nut, or they will be buckled. When adjusting it, make sure it is as tight as possible on the nut to be turned. Once the corners are taken off a nut it may be very difficult to move. Wash your adjustable in petrol occasionally and then lubricate it so as to keep the adjustment free.

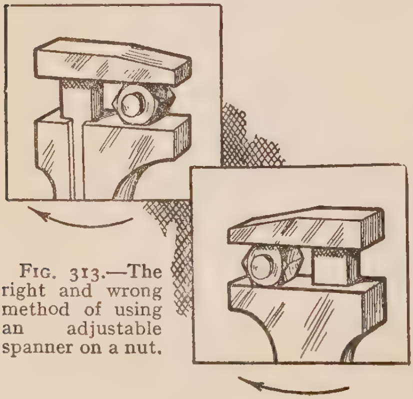


FIG. 313.—The right and wrong method of using an adjustable spanner on a nut.

A screwdriver is an instrument which is frequently misused by motorists. Before attempting to turn a screw it should be ascertained that the screwdriver blade is well down in the screw slot. If it rides on the edge through being too blunt, it will injure the slot and make the screw difficult to extract. A few strokes with a file will keep a screwdriver in condition. Where a particularly stiff screw is to be removed, it is useful to put pressure on the handle of the tool with one hand, and with an adjustable spanner on the flat of the blade, turn the screwdriver with the other. The end of the blade will have more grip if it is free from oil, and you can make certain of this by heating it for a

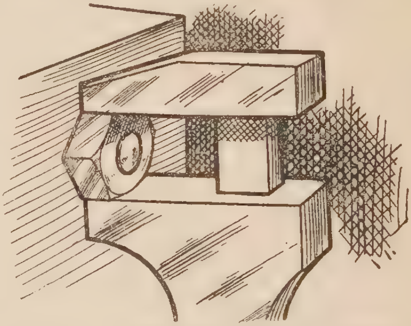


FIG. 314.—Don't place the jaws "end-on" the nut.

moment before use on a hard screw. Ratchet and worm-drive screwdrivers are now very cheap and save a lot of time. The motorist's tool kit should include a very small screwdriver for use on the electrical equipment of the car. A blade about ⅛ inch wide is the most useful, as switches and junction boxes often have the screws recessed. A wide handle is better than a thin one, as these latter do not offer much grip if the screw is at all stiff.

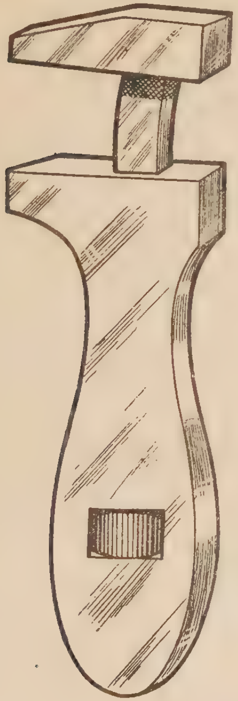


Fig. 315.—The use of an adjustable spanner on too large a nut will bend the beam.

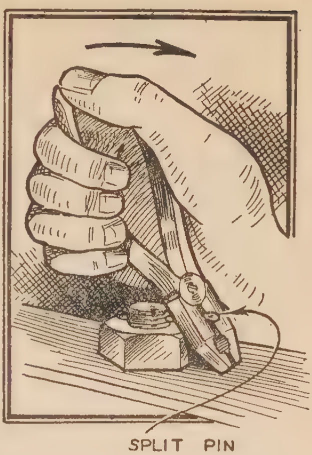


Fig. 316.—Withdrawing split pin by levering it against the nut with a pair of pliers.

The Use of Pliers.—Pliers are also misused members of the motorist's tool roll. Under no circumstances should this tool be used for turning nuts or screws. Its function is to grip and to cut. There are two gripping surfaces on the

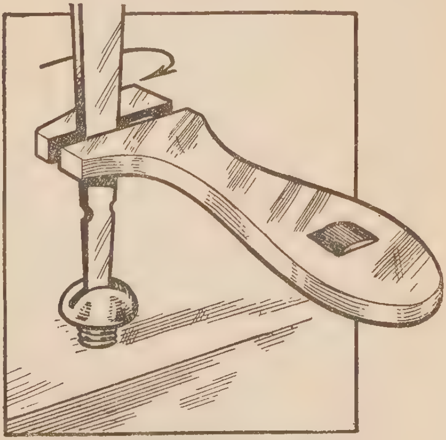


Fig. 317.—Turning the blade of a screwdriver with an adjustable spanner.

usual motorist's pliers. The nose of the tool is used for split pins and the like, and further down the jaws there is a recess for holding pipe or rod. This recess has serrated teeth to provide a better grip. When holding a rod with this part of the pliers, a better grip will be obtained if the tool is used at right angles and pressure applied and then turned to a slightly more acute angle. When removing a difficult split pin it should be gripped with the cutting edge of the pliers. Now if the nose is allowed to rest on the side of the nut or some other part of the car, and pressure is applied to the handles, great leverage can be applied. Do not grip the pin so tightly that the head is cut off in the process.

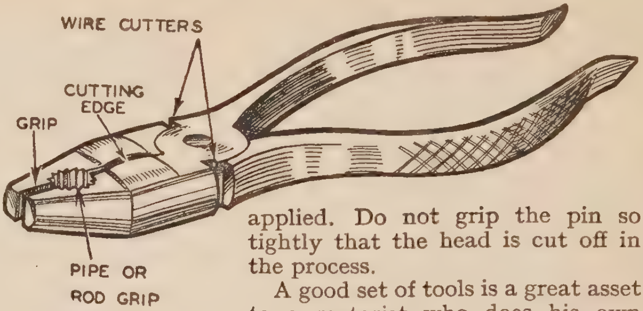


FIG. 318.—A pair of pliers may be put to a number of uses, as shown above.

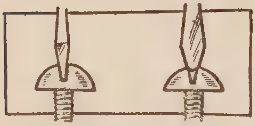


FIG. 319.—(*Left*) The right way to use a screwdriver and (*right*) the wrong way.

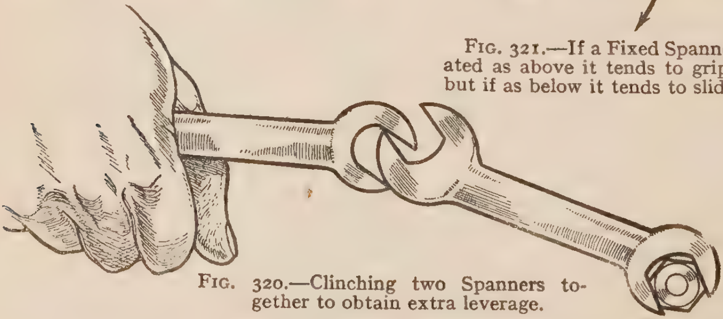


FIG. 320.—Clinching two Spanners together to obtain extra leverage.

A good set of tools is a great asset to a motorist who does his own mechanical work. Always be on the look out for a well-balanced, useful tool, and a very handy collection can soon be built up without any great expense. Never lend tools. They are like books and rarely find their way home again. In America most garages display a sign stating that the man who lends tools is out ! It is a wise policy.

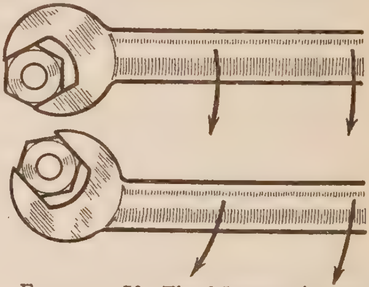


FIG. 321.—If a Fixed Spanner is operated as above it tends to grip the nut, but if as below it tends to slide off.

SPARK GAP.—The air space intervening between any two conductors, across which a high-tension current may jump, thereby producing a spark.

The term is most commonly applied to the spark gap existing between the electrodes of the sparking-plug; also, to the make-and-break contacts of the magneto or the coil.

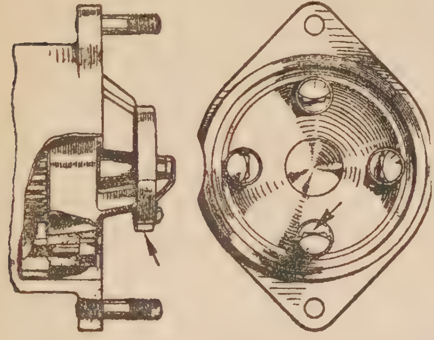


FIG. 322.—A Spark Gap type of Four-cylinder Distributor. The arrows indicate the spark electrodes.

SPARKING-PLUG.—A specially constructed metal plug which screws into the upper portion of the cylinder. It possesses two or more electrodes across the points of which the electric spark passes for the purpose of igniting the mixture within the cylinder.

Abbreviation: *Plug*—which see.

SPARK LEVER.—See *Ignition lever.*

SPECIFIC GRAVITY.—A scientific term which expresses the relative weight of any substance (usually a liquid) compared with an equal bulk of water under the same conditions.

For specific gravity measurements, water is taken as unity (*i.e.* 1·000). Liquids lighter than water have a specific gravity of less than 1; liquids heavier than water possess a specific gravity of more than 1.

Specific gravity measurements are very important in controlling the properties of motor fuels, oils, acids, etc.

Abbreviation: *S.G.*

SPECIFIC HEAT.—A term relating to the heat-absorbing qualities of metals and other materials.

The specific heat of a substance is the amount of heat (in calories) required to raise the temperature of one gram of the substance one degree Centigrade.

The specific heats of iron, copper, and aluminium are 0·119, 000·4, and 0·219 respectively. Hence, aluminium possesses the greatest heat capacity of these three metals.

SPECIFIC RESISTANCE.—The resistance offered to an electric current by an inch or centimetre cube of a substance (generally a metal), the current being applied to two opposite faces of the cube.

The term is used largely in connection with the comparison of resistances of various metals and resistance alloys for coil-making, etc.

SPEEDOMETER. — An instrument which measures the speed at which the car is travelling. Speedometers usually embody, also, a mileage recording mechanism. The accuracy of reading of a speedometer depends upon the tyres being inflated to such a pressure that they maintain their rated diameters. Unless this is ensured, the speedometer will read fast. The limit of accuracy is about 5 per cent with the magnetic type, and 2 per cent with the centrifugal type.

SPEEDOMETERS.—In general, car speedometers fall into two distinct classes as regards their mode of operation, though there are, of course, very distinct differences between the models of different makers.

The two general classes of speedometer mechanism are, first, the centrifugal and, secondly, the magnetic types.

In the governor of a gramophone motor three metal weights rotate at a high speed, and, in tending to fly outwards under the influence of centrifugal force, control the speed of the motor. In the centrifugal type of speedometer the identical principle is made to serve a different purpose. A ball governor, which is driven by the flexible shaft is employed, and as shown in the illustration, the weights on the governor tend to fly farther apart as the speed rises. In flying outward the weights draw a collar to which they are attached along the driving shaft, and the movement of this collar is transmitted by means of a geared quadrant, or by some other suitable device, to the needle, which indicates on the face of the dial the speed of the drive.

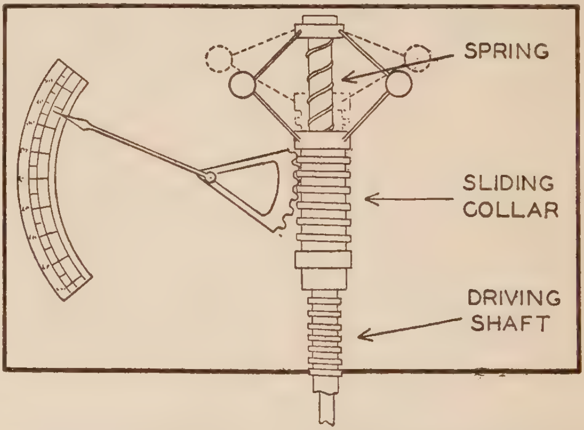


Fig. 323.—An illustration which shows diagrammatically the principle of operation of a centrifugal type of speedometer.

As is to be expected this principle is made the subject of more than a few patents, and the various instruments of the centrifugal type, all vary considerably as regards their particular application of this principle.

The Magnetic Type.—In the magnetic type of instrument there is a circular cup-like permanent magnet which is coupled directly to the driving shaft of the instrument. Surrounding this, but at no place touching it, is an outer metal cover which fits down over the circular magnet, and which is usually made of aluminium or copper. The miles-per-hour figures are inscribed on the outer edge of this cover and the cover is so fitted that it is perfectly free to revolve against the tension of a small hair-spring.

The construction is shown in the diagram. Let us consider, now, what happens in a speedometer instrument of this type. The inner permanent magnet is rotated by the drive of the instrument. In rotating it sets up small eddy currents of magnetism around it, and these tend to spin the non-magnetic outer cup or cover against the tension of the hair-spring. The intensity of the magnet's pull is directly proportional to its speed of rotation.

Hence, it is an easy matter to arrange for the inscribed figures on the outer rim of the non-magnetic cover to give an accurate reading of the speed.

In both the classes of speedometers described above—centrifugal and magnetic—the actual recording and adding-up of the number of miles travelled is carried out by a train of worm wheels and pinions having numbered discs attached, and, in this respect, both the centrifugal and the magnetic types of instrument operate very similarly.

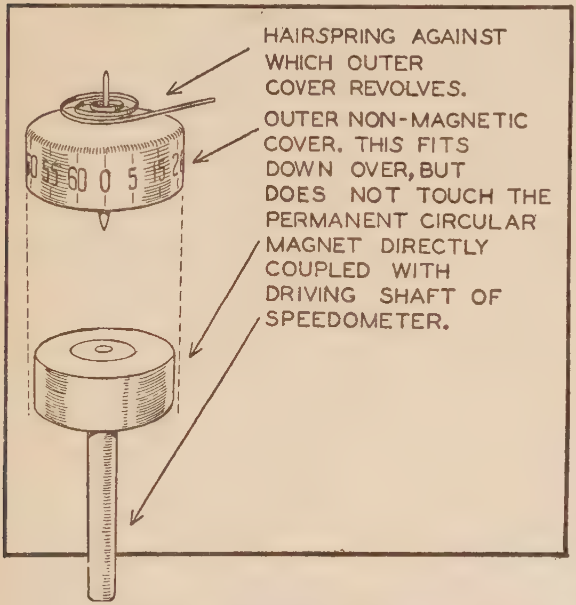

HAIRSPRING AGAINST WHICH OUTER COVER REVOLVES.
OUTER NON-MAGNETIC COVER. THIS FITS DOWN OVER, BUT DOES NOT TOUCH THE PERMANENT CIRCULAR MAGNET DIRECTLY COUPLED WITH DRIVING SHAFT OF SPEEDOMETER.
60
0
5

FIG. 324.—The magnetic type of speed indicator has two main components which are shown here.

Mileage and trip recorders are merely mechanical details of the speedometer. They stand in very little relation to its operating principles, for, with certain patent modifications, they are applicable to either types of instrument.

The making of a speedometer is a task which calls for accuracy of workmanship. In high-grade instruments the accuracy of construction is very great indeed, the maximum permissible error in the dimensions of any working part being ·01 mm., which, being interpretated, is two-hundredths of a millimetre. Only the very best watches and chronometer movements of clocks reach anything like such accuracy in construction.

Attention Required.—A good speedometer will last for many years. Nevertheless, it should be returned to its makers every two or three years for re-lubrication, if it is desired to maintain the instrument in the best of condition.

Keep the speedometer drive in good condition, and if the instrument is at all worthy of its name it will usually last as long as the car.

SPHERICAL JOINT.—A type of universal joint comprising, essentially, a metal sphere held between two opposing arms or members.

See *Universal joint.*

SPIRAL BEVEL WHEEL.—A bevel wheel whose teeth are cut in curved formation. The use of these wheels in a bevel drive makes for great silence in running. (See *Differential.*)

SPIRIT.—A term loosely applied to motor fuels of a light nature, such as petrol.

SPLINED SHAFT.—A shaft in which keyways or slots are cut, thereby allowing a gear-wheel to be driven by the shaft and at the same time to be moved along the shaft at will. Employed in gearbox construction.

SPLINES.—The name given to grooves formed on a shaft.

SPLIT PIN.—A small pin, or piece of metal, having its end divided. It is passed through a hole drilled through the bolt after the nut has been screwed up. The divided end of the split-pin is then opened up and pressed back over the nut, thus making it necessary for the nut to shear off the pin before it can become loose.

SPOKE.—A bar, rod, tube, or wire extending from the centre, or hub, of a wheel to a point on its rim, its purpose (along with the other spokes) being to give strength and rigidity to the wheel-assembly by tension or compression.

SPONTANEOUS IGNITION.—The state of affairs existing in a detonating engine in which the mixture, owing to faulty conditions, is heated up by its compression to ignition point and then ignites spontaneously.

Spontaneous ignition represents a true explosion. The entire mixture bursts into flame at one time. Contrast this with the normal ignition of the fuel mixture whereby the flame spreads evenly (although rapidly) through the mixture from its point of ignition.

See *Detonation.*

SPOTLIGHT.—A small electric lamp mounted, usually, on a universal joint, and thus being capable of having its rays directed in any required direction. Spotlights generally have special reflectors fitted to them.

SPRAG.—A device for preventing a car from moving backwards down a steep hill, either from a stationary position or in case of brake failure. It usually consists of a ratchet mechanism acting directly upon the engine transmission of the car, thus preventing its motion.

SPRAY LUBRICATION.—Name given to the simplest and oldest system of engine lubrication in which oil contained in the crank-chamber is, by the rotation of the crankshaft, thrown up and distributed in the form of a spray over the lower parts of the engine. Sometimes referred to as " Splash Lubrication."

SPRING GAITERS.—Name used to describe leather, or fabric, covers sometimes used for enclosing the leaf-springs of cars and thus protecting them from the inroads of dirt and grit.

SPRINGS.—In motoring the term is usually applied to tempered steel pieces so connected together that they strengthen one another and at the same time permit of the acting of the natural springiness of the metal, thus absorbing much of the road vibration of the vehicle. Such springs are usually mounted between the frame and the axles, and they exist in many different types.

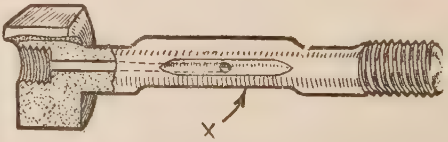


FIG. 325.—Showing how wear affects the Shackle Bolts.

SPRINGS AND SHOCK ABSORBERS.—*Types of Leaf Springs.*—Five types of leaf-springs are in use at the present time: the full-elliptic (Fig. 326), the quarter-elliptic (Fig. 327); the half-elliptic (Fig. 328), the three-quarter-elliptic (Fig. 329), and the cantilever (Fig. 330). Of these the semi-elliptic is the most popular. The term semielliptic is not strictly accurate, because when springs of this type are fitted they are practically flat when the car is fully loaded.

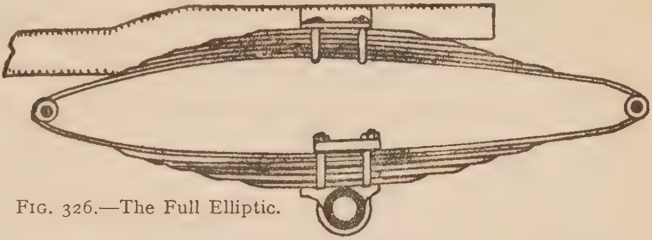


FIG. 326.—The Full Elliptic.

Types of Shock Absorbers.—Shock Absorbers are of two types, those which check the compression and rebound off the spring, and those which check only the rebound. Shock absorbers of the rebound type may be divided into two distinct classes: hydraulic or fluid type, and the purely frictional type.

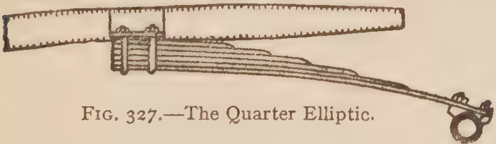


FIG. 327.—The Quarter Elliptic.

A wide variety of shock absorbers are available, but all aim at the same object—controlling the action of the spring. Two popular types are shown in Figs. 331 and 332.

The Hydraulic Shock Absorber.—In this type, when the axle moves, oil is forced from a reservoir through a small vent in the shock absorber by means of a flat vane or a piston type of plunger, so that when the axle movement is slight the oil is allowed to pass through this small vent with a minimum of friction. When, however, axle movement is rapid, as, for example, when the car is travelling over a rutty road surface, the small vent offers considerable resistance to the flow of oil, so restriction or delaying the movement of the axle.

Frictional shock absorbers are of several types; one very popular type consists of a pair of arms, one of which is fixed to the chassis and the other to the axle, and having friction discs at the hinge or pivot. The tension between these friction discs is, of course, adjustable to individual requirements. Another well-known type of frictional shock absorber has a belt, and the action of the spring tends to coil it tightly around segments supported by a very stiff spring.

Auxiliary Springs.—Auxiliary springs are usually fitted to replace the spring shackles and consist of coil springs which are sometimes enclosed in a steel barrel or cylinder.

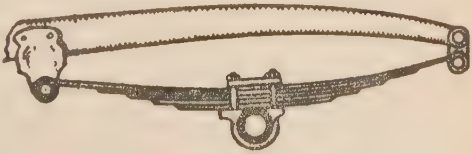


FIG. 328.—The Half Elliptic

Shackles.—The usual type of half-elliptic spring consists of a main or master leaf supported by a centre pin and provided with rebound clips. The master leaf is bent round at its end to form eyes, and into these eyes are pressed either bronze or steel bushes. The shackle pins work in these bushes. The spring shackle ends which connect with the chassis are also bushed, and oil-ways are cut in the shackle pins themselves, through which oil is forced by means of the grease gun. The movement of the shackle is to and fro. In lubricating, therefore, continue to force oil through the nipple until it oozes out round the sides of it. Neglect in lubrication results in rapid wear, shake in the pins, and eventually the spring eyes and shackles will have to be bushed. But as the shackle pins themselves are hard, it is seldom that new ones are required as a result of wear. Fig. 333 shows a typical shackle pin.

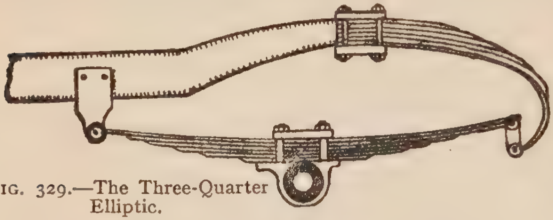


Fig. 329.—The Three-Quarter Elliptic.

Flexible Fabric Spring Shackles.—These are a comparatively recent introduction, in which the spring movement and the loads occasioned by it are all taken by means of flexible fabric of special construction, and as there is no motion of contacting metallic parts, no lubrication of any sort is required for them. (*See* Figs. 334 and 335.)

Self-Lubricating Shackle Pin Bushes.—Many firms are now adopting shackle pin bushes, which are packed with a strongly compressed graphite grease, and whilst these will run for many thousands of miles without further lubrication, a much better system is that known as the Silentbloc. This consists of an outer and inner bush, the intermediate space being filled with rubber, which receives and absorbs the movement between the two parts.

Shackleless Springs.—The ends of the master-leaf in some designs of leaf-springs are not shackled, but are made flat and slide against flat metal surfaces, which are enclosed in grease boxes; and in others of the same type rubber blocks are used to take up the movement.

Dismantling Springs.—To dismantle a spring, the procedure is as follows: first remove the U-bolts which secure the spring to the axle. Next jack up the chassis until all load has been removed from the springs, when the spring shackles can be undone and the shackle pins knocked out. At this point the spring may be removed bodily and clamped in a vice, close to the centre pin which holds the leaves together. Now unlock the centre pin, and upon carefully opening the

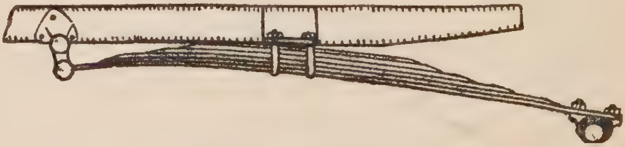


Fig. 330.—The Cantilever.

vice the leaves will gradually separate. Do not make the mistake of unlocking the centre pin without first clamping the springs between the jaws of the vice, otherwise the springs may fly apart rather suddenly and cause damage. To reassemble the springs after they have been thoroughly cleaned, rubbed up bright with emery cloth and greased, carefully lay the leaves in their correct order, one upon the other, and compress them between the jaws of a vice, care being taken to leave the centre bolt holes clear so that the bolt can be pushed in easily. This is easily accomplished by threading all the plates as they are laid together on to a piece of round rod about the same size as the bolt hole, and about 8 inches or 9 inches long (*see* Fig. 342). When the spring is compressed in the vice the piece of rod keeps the holes in line, and the rod can easily be removed when the spring is compressed and the centre bolt is secured in its place.

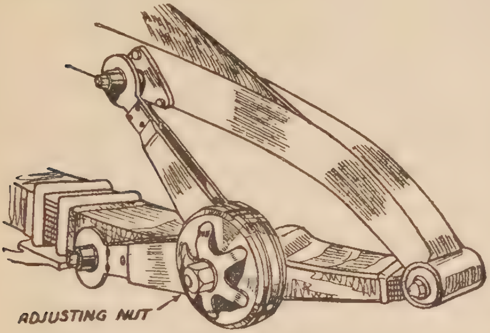


Fig. 331.—Friction type Shock Absorber, easily adjusted by means of a spanner.

Replacing a Broken Spring.—Fig. 341 shows a method that facilitates the replacing or removal of a broken leaf, and the assembly of the leaves without clamping. The leaves are assembled star-fashion, as shown, about the centre bolt. The nut is easily screwed on for a thread or two, after which the leaves are brought into their proper position and the nut tightened.

Repairing Broken Springs.—It often happens that the repairer is called upon to "jury rig" or patch up broken springs so that the owner of the car, who may not be able to wait the arrival of spares, can proceed. An effective temporary repair can be made in the following way:

Assume that the fractured leaves are the three upper ones, and the line of the fracture, as is usually the case, is across the hole of the clips. Make a plate, shaped as shown in Fig. 338, from ¾ inch steel and insert it above the centre of the spring, the slotted ends and the clip bolts locating it, and the yoke bars holding it firmly in place, clamping the plate, axle, and spring together.

Although this repair is only to be considered as a temporary one, quite often it will prove lasting, if skilfully done.

Fig. 336 indicates a front spring which has snapped between the dumb-iron and the axle. This fracture lets the end of the axle nearest

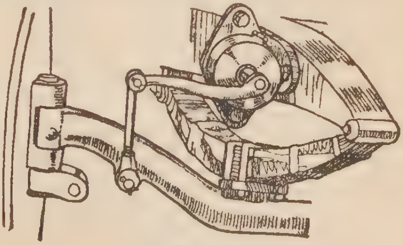


Fig. 332.—A different type of Shock Absorber.

the damaged spring go backwards several inches, and is equivalent to putting the steering on full lock towards that side. A car to which this happens will probably plunge straight off the road. Fig. 337 shows a different mishap, which is attended by similar results, though in this case the driver will usually have sufficient warning to save his car from a smash. The pin through the centre of the spring has sheared and the axle being held to the spring only by encircling clips, is left free to work backwards along the spring, until it is forced into such a position that the steering is on full lock towards that side.

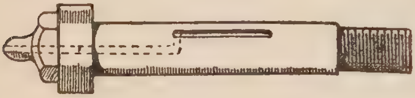


Fig. 333.—A typical Shackle Pin, showing the grease groove.

Both of these possible accidents may be avoided by fitting a wide flat belt of leather, doubled and secured, over the spring. By acting as a temporary radius rod between the dumb-iron and the axle, this method prevents the axle end from being forced backwards.

Spring Camber. — When the leaves of a spring are taken apart it will be noted that their camber is greater individually than when they are assembled as a unit. It may be noted that some of the leaves have flattened out, which will necessitate either replacing the leaf or resetting the old one. In the cases of some of the leaves, it may be necessary to retemper them.

Flattening of the Spring.—After a considerable number of miles the leaves tend to become fatigued, and they soon flatten out again after resetting and tempering. This trouble can be remedied by reinforcing each set of springs with one or more extra leaves, which are usually obtainable from the makers of the car for that purpose. The flattening of a spring reveals itself by the shackle. Instead of being vertical, it becomes inclined (*see* Figs. 339 and 340).

Repairing Worn Spring Eyes.—If the spring eyes are not too badly worn they may be reamed true and new pins fitted. But if this simple course is impracticable, owing to risk of weakening the springs unduly, new top plates must be obtained, or the eyes of the old ones must be repaired by welding, machining, hardening, and tempering. Considering the importance of the job, new plates are preferable. Take care when fitting the new pins to

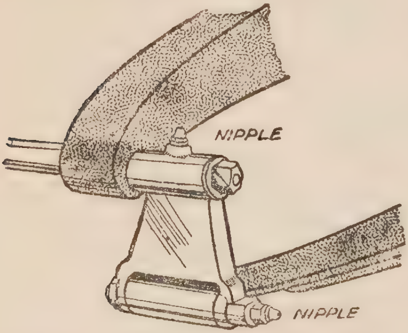


Fig. 334.—Spring Shackles lubricated by a Grease Gun.

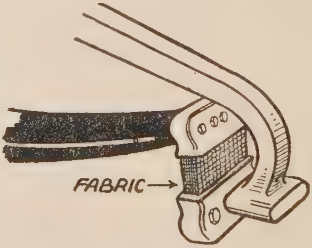


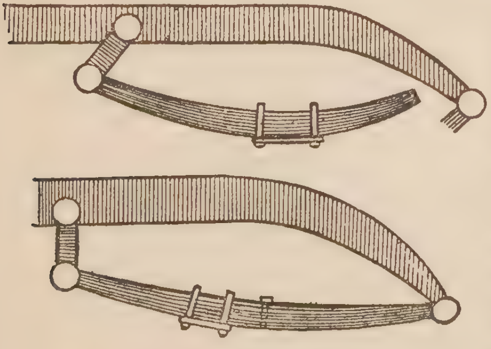
Fig. 335.—A Fabric Shackle, like the above, does not require lubrication.

provide these with grease lubricators or nipples, or early recurrence of the trouble will be experienced.

Renewing Spring Bushes.—A special tool is available for the process of removing and inserting the spring-eye bushings. After removing the spring shackles this tool is placed over, and by turning the handle the old bush is squeezed out, and the new bush in at the same time.

Spring-Centre Breakage.—Usually it will be found that when a break does occur it does so at the centre of the spring, at the point where the securing pin holding the leaves together passes through them. Quite often this breakage is due to neglect in allowing the spring clips to come loose. When it is necessary for the owner of a car to proceed quickly after the springs have broken in the centre in the manner already described, the insertion of a tyre lever between the clips and the main leaf will act as a get-you-home remedy.

Cleaning the Leaves.—If a forge is included in the garage equipment, hardened grease and rust may best be removed and the spring rapidly cleaned by keeping each leaf on the move in the forge fire and gradually burning off all traces of rust and grease. The square end of a file will hasten this process, but take great care not to draw the temper of the spring by allowing it to get too hot.



FIGS. 336 and 337.—Two common forms of spring failure.

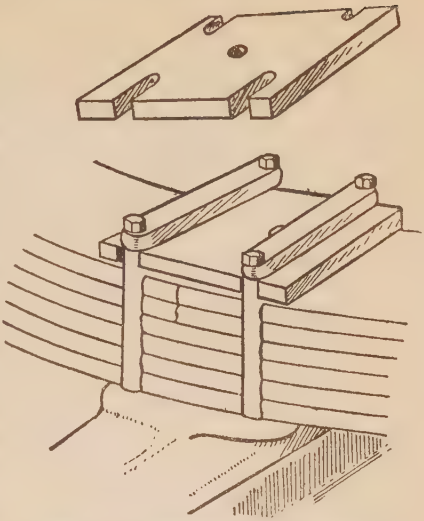


FIG. 338.—Showing the method of effecting a temporary repair, when the top leaves have broken in the centre.

Securing the Springs to the Chassis.—Before refitting the springs to the chassis, opportunity should be taken to examine the shackle pins for wear, and to make certain that their oil passages are quite clean and free before replacing them. When refitting the spring it is most important to make quite sure that the U-bolts are screwed up quite tightly and locked into place by means of a castellated nut and split pin, or any of the other locking devices available.

Of the more important components of a car, the springs are perhaps the most neglected, and very often, unless they openly rebel by issuing rusty squeaks, they are allowed simply to rub themselves to pieces for want of lubricant.

Spring Gaiters.—The fitting of spring gaiters lengthens the life of the spring and lessens the amount of attention required. These are of three types : one type consists of a leather casing with a grease nipple, and attached by means of four straps secured to that part of the gaiter which covers the bottom of the spring. Grease can thus be forced into every part of the spring without removing the gaiter. Simple leather gaiters are first packed with grease and laced together underneath the spring. A third type consists of two channel members which overlap one another when fitted above and below the spring. These, of course, are filled with grease, and have the great advantage of being quickly detachable. Some owner-drivers are under the impression that because their springs are well gaitered they need no more attention, and they expect the springs to lubricate themselves. Gaiters, to the writer's mind, are an excellent investment ; but, like the springs, they, too, require attention sometimes, and if of the leather variety, should be oiled occasionally with castor oil, neat's foot oil, or both, in order to keep them soft and flexible, and prevent them cracking up. The lacings should also be periodically inspected and renewed if necessary, as, should these break, water may be trapped inside the gaiter and cause rust.

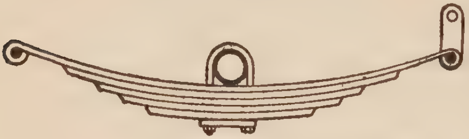


FIG. 339.—The Spring normally loaded. Note upright shackle.

If a little extra attention be paid to the oiling of the springs, this will not only tend to lengthen their life, but the driver and the occupants of the car will be saved much of the jolting and discomfort due to riding on dry springs.

Spring Harshness.—A defect which the garage man is frequently called upon to remedy is harshness of spring action. If the car is reasonably new this may sometimes be remedied by removing one or more of the leaves, having first ascertained that the harshness is not due to maladjustment of the shock absorbers. Quite often, however, it will be found that this harshness is due to negligence in keeping the leaves of the springs properly lubricated ; the springs should be lubricated at least once every 5,000 miles. This attention will prevent rust forming between the leaves and so opposing resistance to the sliding of the leaves one upon the other. This is bound to result in harshness or stiffening up of the springs, and when the complaint is investigated an inspection will reveal what is wrong, and the remedy to apply.

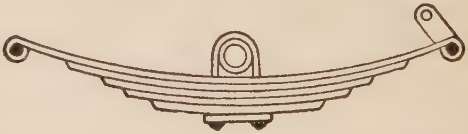


FIG. 340.—The Spring loaded. Shackle inclined.

Seized Shackle Pins.—The most common cause of spring harshness is a seized or partially seized shackle pin. By gently rocking the body a seized or partly seized shackle pin reveals itself by a prominent squeak; the remedy here is obvious.

Weak Springs.—It sometimes happens after 15,000 miles of service that the springs become weak, and this weakness manifests itself in a tendency of the car to heel over at an excessive angle when turning a corner or taking a bend. A test run on the car will indicate whether the weakness is general to the four springs or to one or more of them, and by taking left- and right-hand turns rather sharply the weak springs will be discovered; a slight amount of roll, however, must be allowed, if the car is to be comfortably sprung.

Tyre Pressure and its Effect upon the Suspension System.—Many complaints regarding spring harshness are, upon investigation, found to be due to over-inflation of the tyres; and sometimes, if the tendency to harshness is not too pronounced, running the tyre slightly under-inflated will effect a cure, although it will have a mild effect upon the life of the tyre.

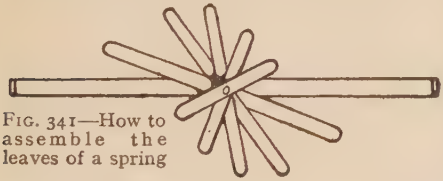


FIG. 341—How to assemble the leaves of a spring

The Spring Anchorage.—Sometimes an owner will complain that he feels an occasional jolting, and this is frequently due to a loose spring anchorage on the axle. This defect, however, is usually accompanied by a slight steering wobble.

Back Wheel Dither.—A defect sometimes found is that the rear portion of the car tends to slide away when the car is steered round a corner. This is nearly always due to weak springs, which are too flexible, and too narrow in width. The fitting of shock absorbers will improve this defect, although it will not entirely get rid of it. A more satisfactory method is to have a new set of springs made of greater width.

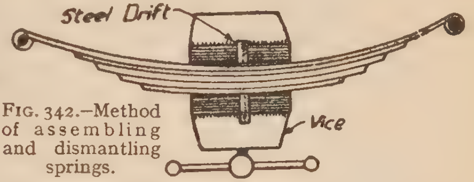


FIG. 342.—Method of assembling and dismantling springs.

Spring Rattle. — An annoying complaint, which the garage man is called upon to investigate, is a spring rattle or click when the suspension strikes a pot-hole. This is really due to side play between the spring eye end and the shackle, so that when the shackle pins are being attended to, the side clearance between the shackles and the spring eyes should be tested, and washers of suitable thickness should be inserted if no other means of adjustment are provided. In some makes of cars nuts are provided to take up this end play. In some cases it will be noted that a lock-nut is provided on the right. This is slackened, the main shackle bolt-

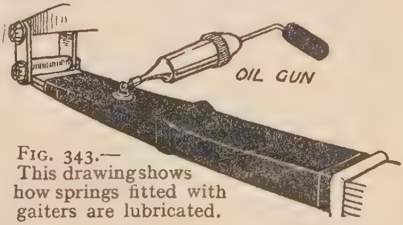
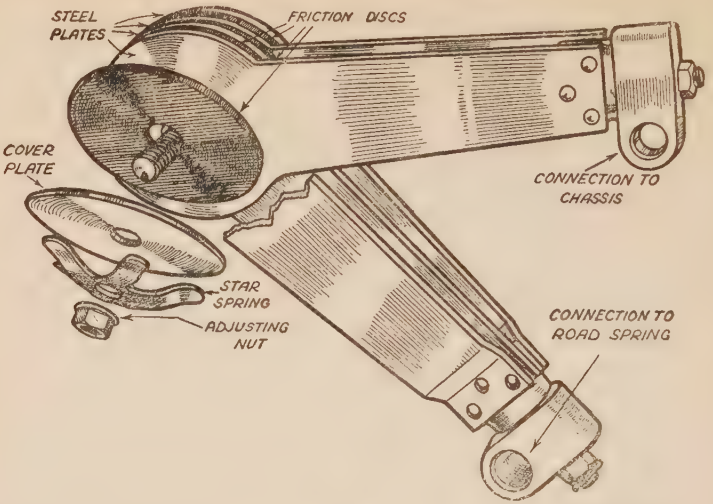


FIG. 343.—This drawing shows how springs fitted with gaiters are lubricated.


STEEL PLATES
FRICTION DISCS
COVER PLATE
CONNECTION TO CHASSIS
STAR SPRING
ADJUSTING NUT
CONNECTION TO ROAD SPRING

MODERN SHOCK ABSORBERS

Fig. 344 (*above*).—Constructional details of the André friction type of Shock Absorber.

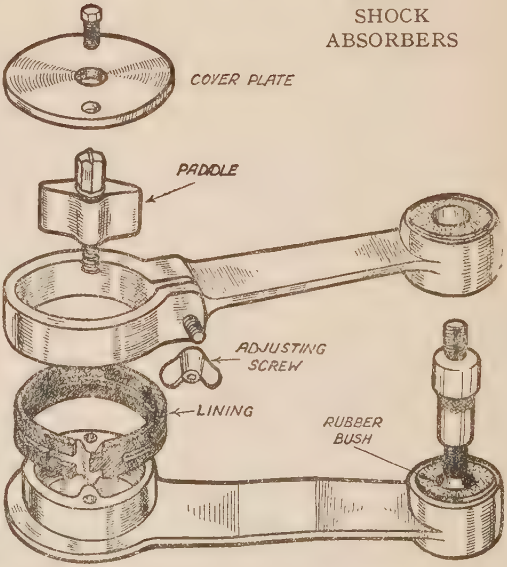

COVER PLATE
PADDLE
ADJUSTING SCREW
LINING
RUBBER BUSH

Fig. 345 (*right*).—A Dissected view of Smith's Shock Absorber.

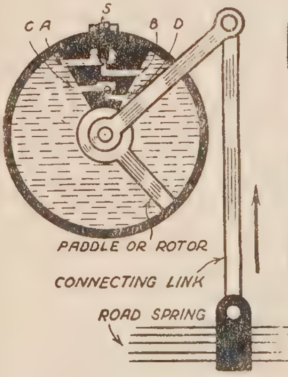

S
C A
B D
PADDLE OR ROTOR
CONNECTING LINK
ROAD SPRING

Fig. 346.—Diagram showing the action of the hydraulic type of Shock Absorber.

nut is screwed up, and then the lock-nut is tightened to secure the main bolt. This should not be tightened up excessively, but, after locking up reasonably hard, should be slacked back about a quarter of a turn and the lock-nut finally tightened.

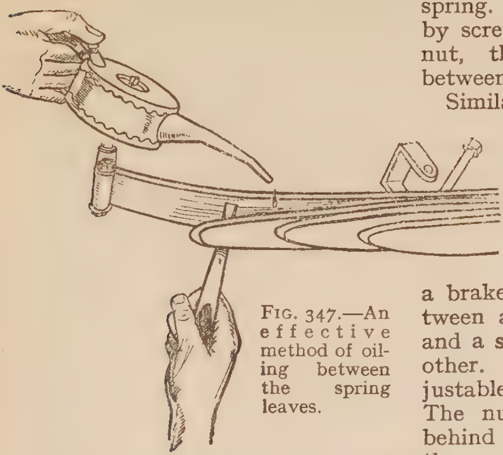


FIG. 347.—An effective method of oiling between the spring leaves.

Shock Absorber Design.—Shock absorbers are of two main types, friction and hydraulic. The usual type of friction shock absorber is double-acting and gives the same resistance in both directions of spring deflection. It usually consists of a number of metal plates interleaved with discs of hardwood or of fibre. Fig. 344 gives a good example of this type of construction and illustrates the André shock absorber. The metal plates are extended to form arms, alternate plates being joined together. One arm is connected to the side of the chassis frame and the other to the road spring. Flexion of the spring thus causes a scissor-like movement of the two arms. Separating the metal plates are round discs of the friction material, the whole assembly of plates and discs being threaded on to a screwed spindle and clamped tightly together by means of a nut and star spring. The pressure can be varied by screwing up or unscrewing the nut, thus varying the friction between the two arms.

Similar in principle to the André is the Smith's shock absorber as fitted to many Morris cars a year or two back. It is illustrated in Fig. 345. In this case the friction material is in the form of a band similar to a brake lining. This is placed between a drum carried by one arm and a stout collar carried by the other. The collar is split and adjustable by means of a wing nut. The nut threads on to a screw behind which is a spring so that as the nut is slackened off so the collar opens, while when the nut is screwed up the collar is contracted and grips the lining. Naturally, to increase the damping action of the absorber the nut is tightened up so as to increase the friction. The mounting of the pivoted ends of the arms is by means of spindles passing through rubber bushes and therefore no lubrication is necessary at these points.

The only attention required by these types of shock absorber is very occasional readjustment of the regulator nut to allow for wear of the friction discs or lining.

The Gabrielle Snubber.—In Fig. 352 is shown an entirely different type of shock absorber as fitted to some modern cars. It is of the "snubber" or rebound type and is single acting in principle. It consists essentially of a fabric belt coiled tightly round metal segments supported by a stiff spring. The body of the device is mounted on the side of the car frame and the end of the belt is fixed to the spring or axle. When the spring rises the belt simply coils up like an engineer's tape measure, but on the rebound the friction of the unwinding belt is considerable and prevents a sudden recoil of the spring. This type again is almost fool-proof and needs the minimum of attention.

The Hydro-Telecontrol Shock Absorber.—The advantages of quick and simple adjustment of the shock absorbers of a car can be readily appreciated. Loading, road conditions, and temperature (affecting tyre pressures), may vary considerably and a fixed setting of the shock absorbers can, therefore, only be a compromise. With what is called the Telecontrol system as used on the latest André shock absorbers, it is possible to control the degree of damping from the driver's seat and thus cope with varying conditions as they arise. There are two methods of carrying out the Telecontrol. The earlier one consists of a Bowden cable control from each shock absorber. In place of the ordinary adjusting nut there is a short lever, movement of which carries out the same operation as adjusting the nut on the ordinary model. The lever is connected to a Bowden cable extending to a control lever on the dashboard of the car.

The latest type of control is termed Hydro-Telecontrol and works on much the same principle as do hydraulic brakes. In fact, the internal arrangement of the shock absorbers is very similar to that of a Lockheed brake. As will be seen from Fig. 353, there are two shoes like brake shoes but fitted with wood linings. The pivots of these shoes are fixed to one arm of the shock absorber while the drum on which the shoes act is joined to the other arm. Between the two shoes is a device known as an Hydraulic Expander, which takes the place of the small cylinder and piston of a Lockheed brake. A small pipe leads into the centre of the expander. The other end of the pipe is connected to a control cylinder mounted behind the dashboard. The cylinder is fitted with a piston arrangement worked by turning a milled control knob on the dashboard. The cylinder is filled with special fluid and by screwing down the control knob the fluid is forced along the pipe and operates the hydraulic expander forcing the shoes outward against the drum. There is, of course, a pipe leading from the cylinder to each of the shock absorbers and the pressure which is applied can be seen at a glance by reference to the pressure gauge which is connected to the cylinder and mounted by the side of the control knob. Naturally, with this system the setting of all the shock absorbers is the same, but, if desired, separate controls can be fitted to front and back shock absorbers.

The hydraulic control of shock absorbers must not be confused with hydraulic operation. In the Telecontrol device the shock absorber is essentially of the friction type, although the adjustment is hydraulically controlled. With the true hydraulic shock absorber the resistance medium is a fluid. Movement of the springs causes the fluid to be forced backwards and forwards through a small aperture. By adjusting the size of the aperture the speed with which the fluid can move can be altered, thus varying the resistance which it offers to the movement of the road springs of the car. Fig. 348 shows a typical

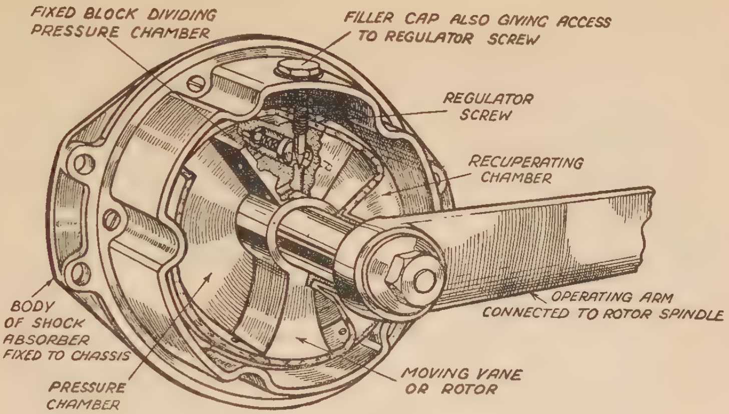
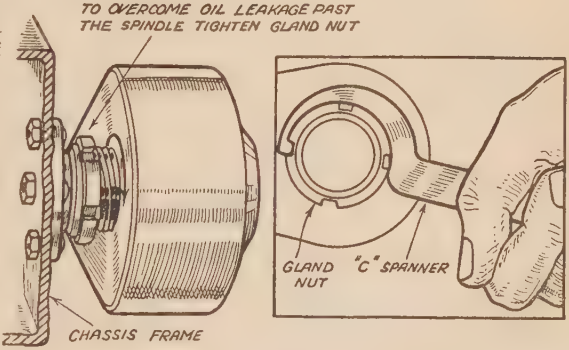
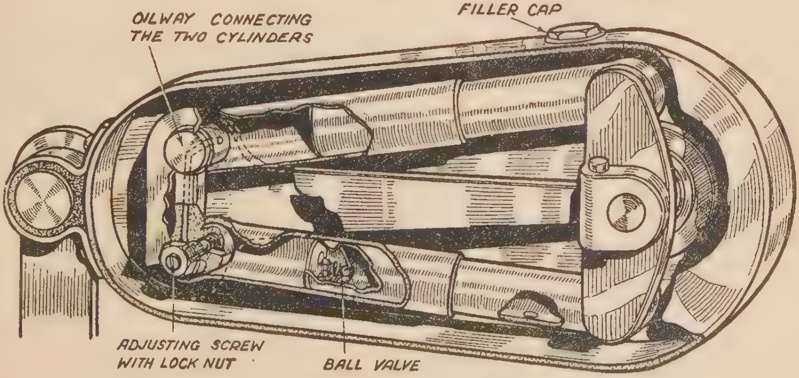

FIXED BLOCK DIVIDING PRESSURE CHAMBER
FILLER CAP ALSO GIVING ACCESS TO REGULATOR SCREW
REGULATOR SCREW
RECUPERATING CHAMBER
BODY OF SHOCK ABSORBER FIXED TO CHASSIS
OPERATING ARM CONNECTED TO ROTOR SPINDLE
PRESSURE CHAMBER
MOVING VANE OR ROTOR

FIG. 348 (*above*).—Cut-away view of Hydraulic Shock Absorber.

FIG. 349 (*right*).—How to adjust the Spindle gland nut on the Armstrong Shock Absorber.

FIG. 350 (*below*).—Constructional details of the Armstrong Hydraulic Shock Absorber.


TO OVERCOME OIL LEAKAGE PAST THE SPINDLE TIGHTEN GLAND NUT
CHASSIS FRAME
GLAND NUT
"C" SPANNER


OILWAY CONNECTING THE TWO CYLINDERS
FILLER CAP
ADJUSTING SCREW WITH LOCK NUT
BALL VALVE

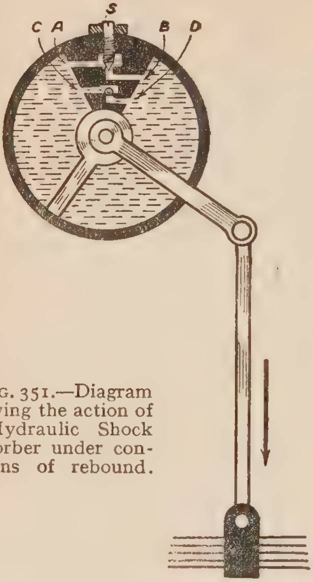


Fig. 351.—Diagram showing the action of a Hydraulic Shock Absorber under conditions of rebound.

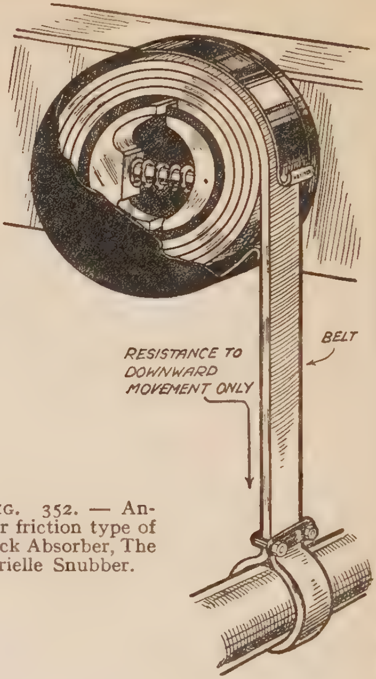

BELT
RESISTANCE TO DOWNWARD MOVEMENT ONLY

Fig. 352. — Another friction type of Shock Absorber, The Gabrielle Snubber.

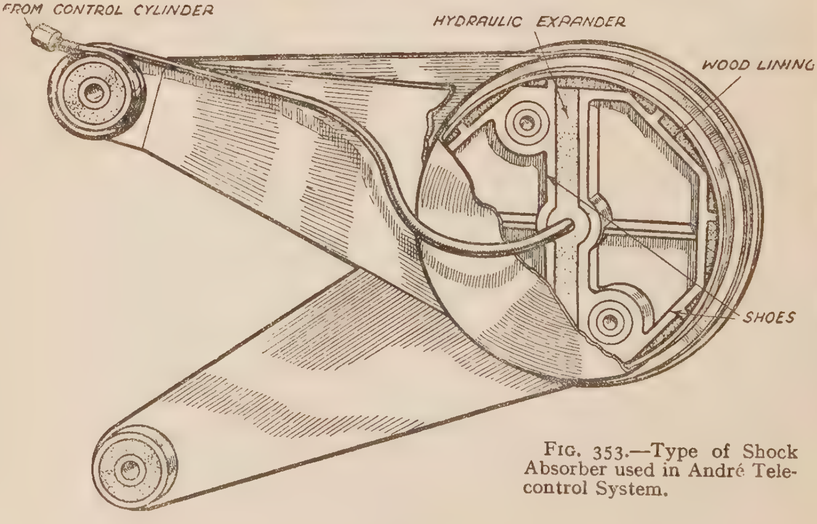

FROM CONTROL CYLINDER
HYDRAULIC EXPANDER
WOOD LINING
SHOES

Fig. 353.—Type of Shock Absorber used in André Telecontrol System.

hydraulic shock absorber, the Luvax, cut away to show the internal construction. To understand the principle of operation, however, it is best first to refer to the diagrammatic sketches given in Figs. 346 and 351. The body of the shock absorber consists of a circular pressure chamber in which a closely fitting paddle sweeps from side to side by the action of the car springs. The paddle is mounted on a central spindle which has an arm at one end connected to the spring by a link or rod. The pressure chamber is divided into two compartments by the paddle below the spindle and a wedge-shaped block of metal above it. This block, which is known as the reacting block has passages drilled in it extending from one side to the other. The whole of the pressure chamber is filled with a special oil. On the upward movement of the road spring as in Fig. 346 the paddle moves over to the right as shown. Oil in the right-hand half of the chamber enters the oilway D, raises the ball valve and passes out through C, without offering any very great resistance to the movement of the paddle, and therefore to the spring. On the return of the spring as in Fig. 351 a different state of affairs prevails, for now the pressure is in the opposite direction due to the reversal of the paddle's movement and the ball valve will automatically close. The only remaining escape for the oil from the left hand side of the chamber to the right hand side is through the passage A-B. This is restricted to a very small opening by the tapered adjusting screw S.

SPRING WASHER.—See *Lock Washer.*

SPROCKET; SPROCKET WHEEL.—A toothed wheel designed especially for operating a chain drive.

STAINLESS STEEL.—The name given to a class of chromium steels containing from 12 to 20 per cent of chromium. When exposed to ordinary atmospheric conditions it is practically rustless.

Stainless steel was originally suggested by Mr. Harry Brearley, of Sheffield, in 1914, but owing to the intervention of the Great War, it was not commercially developed until later.

Steels of this nature are now much used in the manufacture of car fittings.

STALE PETROL.—Term which is used to describe petrol which has been left standing, and which, owing to slow evaporation, has reached a point at which its density militates against its further free vapourisation.

STAMPING.—A metal part of simple or intricate design which has been stamped out from a sheet of metal by means of a machine made for that purpose.

The name is also given to other and heavier parts, which are produced by a forging process, as, for example, heavy "steel stampings."

STAPLE.—A short, U-shaped piece of wire, generally of copper or iron, used for securing insulated wire to a surface. Used, at times in car-wiring circuits.

STARTER.—See *Self-starter.*

STARTER SWITCH.—A special form of electrical switch of heavy construction used for switching on current to the self-starter of the car.

Starter switches usually take the form of a small plunger placed on the instrument-board of the car or else a heavier knob or plunger mounted as a foot-pedal.

STARTER TROUBLES, REMEDYING.—Starter trouble is very much of a real trouble, because it nearly always leads to costly failure all round on account of prolonged heavy discharges that end in a defunct battery.

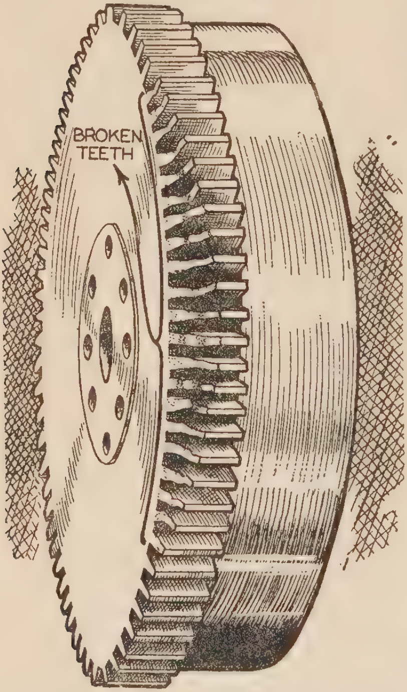


FIG. 354.—The usual form of wear on the teeth of the Starter ring. A fresh lease of life can sometimes be given to it by turning it on its shaft 180°.

Because the starter only runs for a few seconds at a time there is a tendency to neglect it. The bearings are generally phosphor-bronze with insertions of solid lubricant incorporated. There is no need for further application of grease and it will only lead to trouble.

At least every six months the starter should be removed and dismantled. This is the only way in which the owner can know of its condition, as appearance often counts for little or nothing. Owing to the heavy load imposed on the armature shaft, the bearings wear very rapidly, perhaps allowing the armature to foul the field magnets and so produce excessive current consumption. Worn bearings also mean that the pinion wheel does not properly mesh with the ring on the flywheel. The designer has already allowed clearance to the limit in this direction, therefore any further play means that the starter pinion will engage only the tops of the teeth and break them away far more rapidly than if all is in order. This state of affairs ends in the pinion riding *on* the teeth instead of between them. The more the bearings wear, so this condition will be accelerated.

Often, owing to the starter being semi-enclosed, the commutator becomes pitted through frequent condensation. Every time the motor is used the heat clears off these acidical vapours only to prepare a new surface for their further formation. There is no remedy, but the unit should be examined more frequently.

The Bendix Spring.—There is a heavy mortality amongst Bendix springs, mostly due to advanced ignition. Under such conditions the moment the engine fires the spring receives a shock because the action is suddenly reversed. The same applies should the starter button be pressed with the engine running. First, the motor turns the pinion through the spring, then the pinion turns the motor again through the spring. If possible it is an advantage to switch on the engine *after* pressing the starter button. This will ensure that the engine turns over at a speed consistent with the spark. However, it is not always possible to do this as the button and switch, owing to position, will not permit. If this is so, let the starter turn the engine over a few times to free its movement, then operate the starting apparatus in the usual manner. When the engine is warm there is little risk, except with engines that can be advanced by hand and left in that position. Engines with automatic advance need not be troubled about at all.

The spring does not always break at the moment of the partial backfire, but is deformed and will eventually give out when least expected. Whenever a new spring is fitted, fit a new bolt and locking washer at the same time. Attempting to use the old washer is inviting trouble, as it is sure to allow the bolt to become loose. Always rescue broken bolts and springs from the flywheel pit, as they are likely to get caught up, jam between the flywheel and the crankcase and make your motoring a little dearer still.

Examine the Starter Motor.—The pinion is always a loose fit on the shaft and an allowance of ·020 inches is the usual play. Any more than this will permit the pinion to stick to the collar at the end of the shaft, necessitating removal to dislodge it. It is not an easy matter to determine when the looseness has increased beyond the limit of safety, and it is not advisable to change the pinion and sleeve the first time the trouble happens, but if it sticks a second or third time the change must take place, otherwise it will recur every few hours. The reader can rest assured that many things have been tried to palliate the position, without success. To avoid further trouble change pinion and sleeve.

Damaged Armature Shaft.—At times a backfire will bend the shaft, or it will be bent through engaging whilst the engine is running. If not bent too near the armature it can invariably be straightened. If too near, the act of straightening will produce a kink that precludes further use anyhow.

Obtain a replacement armature, getting an allowance for the old one, according to condition. Straightening cannot be carried out too many times as the steel grain is destroyed and the shaft readily bends again.

It will be noticed that the four-cylinder engine flywheel teeth wear in two places, and the six-cylinder, three. This is due to the compression acting as a brake. The teeth immediately opposite the starter always take the first impulse, therefore wear or break away quickly, especially on cast iron flywheels. Some makers arrange that the flywheel or ring can be turned either one-fourth or one-sixth of a revolution so that a fresh set of teeth are brought opposite the starter pinion, and it is advisable to have this done before worse trouble follows. There are many owners who keep running to garages to have starters released and, every time, are told that the fault lies in the flywheel. A new starter ring is the obvious and cheaper remedy, for frequent releasing of the pinion is costly.

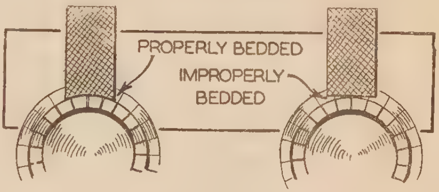


FIG. 355.—Correct and incorrect bedding of the motor brushes.

Armature Troubles.—Defective armatures are rare. Armatures are substantially and amply made, having been designed to pass such large currents that there is little chance of either electrical or mechanical failure. Breakdown comes from outside, such as having the car in gear with the brake on. Keeping the finger on the starting button under these conditions is asking for trouble with any armature.

There is certainly heavy sparking owing to the slow turning movement specially with a cold and gummy engine. The wear on the brushes is also excessive. The brushes should be renewed before they cease to pass enough current to effect a start. They should be carefully bedded in, because of the heavy current which they have to carry; they must also be the right grade for the type of machine—a most important feature.

Bad Switch Contacts.—Much so-called starter trouble is caused by imperfect switching, or imperfect connections. In the early days the switch button was on the floor where the heel of a good-sized boot was bound to push it right home, but when it was moved to the facia board it offered itself to a dainty, delicate push, resulting in imperfect contact and only partial electrical connection of the battery to the starter. This state of affairs is bad for both starter and switch. Always press the button as though you really meant it, and many troubles will cease. Even the remote-control button should be deliberately pressed as it has considerable current to pass notwithstanding the fact that it only operates the starter-switch magnetic circuit. There is quite a heavy flow in comparison to the dimensions, and the fingers are likely to stick and keep the motor revolving, also damaged fingers burn more rapidly as time goes on, and once again there is imperfect electrical connection between battery and motor. Remember that the battery is also having a bad time during these troubles.

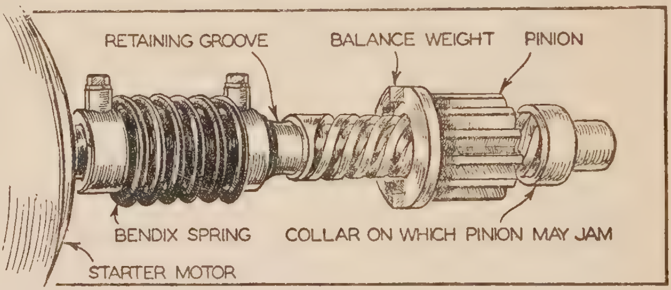


FIG. 356.—Principal parts of the Bendix Starter motor mechanism.

Battery leads and connections are a source of trouble. The current flow to start up a 10-h.p. car is about 175 amperes (equivalent to more than one horse power) and for this reason all leads are as short as possible, but, unfortunately, none too ample in carrying capacity. The reason for the latter is that large cables are unwieldy, difficult to install, and costly.

Some Useful Tests.—Sulphation of the battery terminals will slow the turning movement of the motor. Often the lead post of the battery will appear clean when the wire terminal is lifted off, but it should be scraped with a knife to remove the hard sulphated surface that offers resistance to the current. Battery post and terminal should be vaselined before being replaced.

The current, owing to its proportion, by-passes the ammeter on its path to the starter, therefore this instrument is no indication whatever of failure. A test which will give more than a fair idea of the position of affairs is to place the car somewhere where the lights of the headlamps can be reflected to the driver, such as a white wall. Switch on the lights but not the engine. Press the starter button and watch the lights. If they do not become bright again immediately after the button is released the battery is "down" and requires charging or renewing. If they have come up bright again, but the motor has only turned over slowly, there is trouble in the motor caused by metallic dust, jammed or insufficiently-tensioned brush, or in the armature itself. If the lights do not go down and the motor is either slow or does not respond at all, then there is a disconnection somewhere, perhaps a stuck-up brush, pigtail disconnection from the brush itself or a definite open circuit. If the lights go out either a "flat" battery or a short-circuit through an abraised starter wire is indicated. A temporary disconnection from the terminal on the motor will decide which. When cleaning up remember that a coat of paint is likely to insulate the starter from the frame of the car, which is often the "earth-return."

It should be borne in mind that immediately the starting motor moves the battery voltage drops to at least 4½ on a 6-volt set, and about 9 on a 12 volt set. Even if everything is satisfactory the lights cannot be as bright when the starter is working, but the variation in light is an excellent indication, and is nearly as good as expensive testing apparatus in the preliminary investigation. (See also *Self-Starter*).

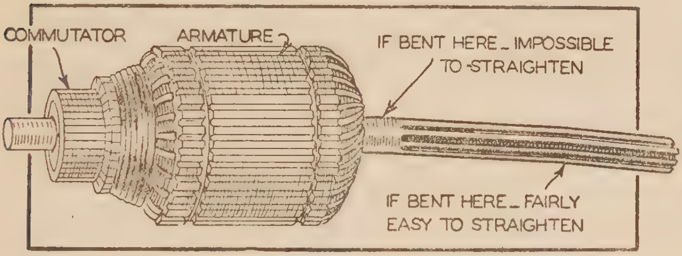

COMMUTATOR
ARMATURE
IF BENT HERE _ IMPOSSIBLE TO STRAIGHTEN
IF BENT HERE _ FAIRLY EASY TO STRAIGHTEN

FIG. 357.—The armature commutator and splined shaft of typical starter motor.

STAUFFER GREASE.—A semi-solid grease sometimes used for the lubrication of relatively slow-moving shafts, such as road axles, whose bearings are not subjected to external heat.

STAY.—A term which denotes a rigid support, generally taking the form of a metal bar or rod.

STEATITE.—A natural silicate of magnesium used in making the insulating portions of some sparking-plugs. It is a white, or yellowish-white, fine-grained material possessing high insulating properties. It is known also as "Soapstone." Finely powdered, it constitutes "French chalk."

STEEL.—In general, steel is a form of iron containing carbon. It contains less carbon than cast iron and more carbon than wrought iron, and, in principle is manufactured either by carbonising wrought iron or decarbonising cast iron.

Within certain limits, the hardness and tensile strength of steel is increased with increase in carbon content.

Steel is very sensitive to the effects of certain additions to it, small percentages of manganese, nickel, chromium, vanadium, titanium, silicon, and other elements modifying its properties to a very great extent. It is by the addition of such substances to steel that the numerous "alloy steels" so much in evidence nowadays as constructional materials are made.

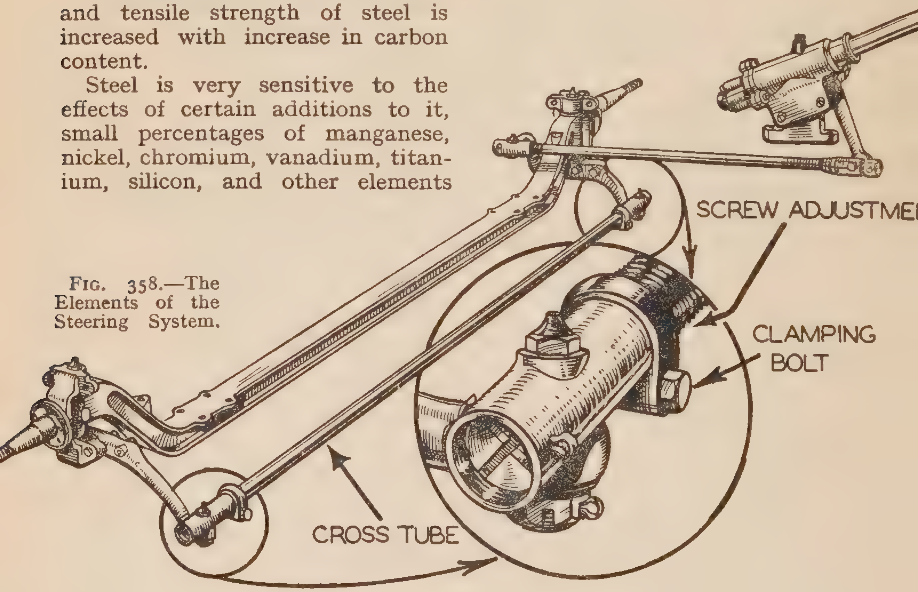


FIG. 358.—The Elements of the Steering System.

STEERING BOX.—Name given to the metal casing which encloses the worm gearing of the steering mechanism of a car.

STEERING COLUMN. — The hollow tube, or column, carrying and supporting the inner steel shaft which controls the steering mechanism of the front wheels, and to the top of which is attached the steering-wheel.

STEERING LOCK.—Name used to indicate the range of angle through which the front wheels of a car can be turned by the steering-wheel.

It is also known as the "Angle of Lock."

STEERING RAKE.—See *Rake.*

STEERING SECTOR. — Name given to a toothed gear having a face the shape of the arc of a circle and the teeth of which engage with the worm gear in the steering box of a car. By means of it the motion of the steering-wheel above is transmitted to the front wheels.

STEERING SYSTEM: UPKEEP AND ADJUSTMENT.—In the section dealing with wobble and shimmy points are discussed as to the proper condition of the steering-heads of the stub-axles, the tie-rod and drag-link connections, etc. These apply to the steering generally and the object should be to keep all working quite easily without any back-lash.

This is just as necessary in the case of a car which does not suffer from shimmy or wobble, as in the case of one which is prone to those distressing ailments, and the instructions and advice apply to the keeping in good order of that part of the steering mechanism.

Toe-in.—The alignment of the wheels, particularly the front wheels, is important. When the front wheels are set for dead straight ahead—the car to travel in a straight line—the two front wheels should be in line or parallel with each other. The tendency when driving the car is for the front wheels to spray out, and in trying to do so they will take up all the back-lash which the combined looseness allows with the result that a line between the rim edges in front of the axle and the same line behind the axle, and at wheel hub height from the ground, will be distances of unequal length. Fig. 359 shows the amount of splay-out which may be present in the wheels of a car after a fair amount of road usage unless adjustment has been made. It will obviously cause excessive tyre wear, and this tyre wear may be on one or other of the wheels or on both: but it is unusual for it to be equal on both. It will be much greater than on the rear wheels in spite of the fact that the rear wheels take the drive.

If we set the wheels dead parallel, by careful measurement with a trammel, that would be theoretically right. But when the car is standing and with the wheels jacked up to allow us to turn them easily we shall not get them in the position which they will assume on the road with the load on them and the back wheels driving them forward. It is a correct practice, therefore, to make the adjustment so that when the wheels and car are inert the fronts of the wheels are nearer to each other by ⅛ of an inch than are the backs. This is known as "toe-in." In Fig. 360, which is a plan view, these measurements are shown. They should be taken from rim to rim, the axle should be jacked up and the wheels free and the wheels should be rotated to see that the rims are not out of plane sideways If they are, the measurement should be from positions on the rim which are normal and not bent out or in. While making the measurement an assistant should press the fronts of the wheels away from each other (or draw the back of the wheels towards each other).

Adjustment for "Toe-in."—The adjustment for "toe-in" is made by lengthening or shortening the tie-rod, B in Fig. 359, and shown diagrammatically in Fig. 361, where A shows the screwed adjustment for the left-hand (it can be right or left) fork joint. The joint is shown in section and enlarged at B. To make the adjustment remove the pin from the joint. Slack-off the lock-nut, turn the pin round, screwing it in or out (according to the adjustment of effective length desired), then lock up the lock-nut, replace the fork on the steering-arm and pin it up and test again between the wheel rims with the trammel.

In the case of tie-rods having ball and socket joints, the procedure is a

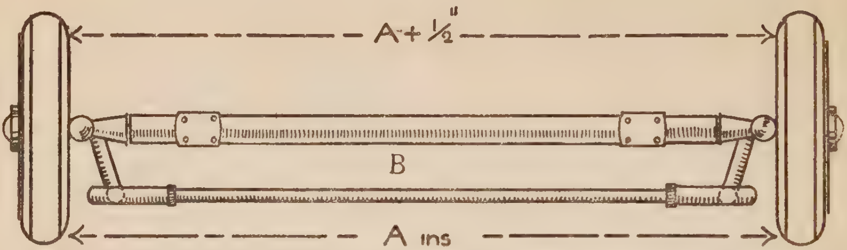


Fig. 359.—The amount of splay-out which may be present in the wheels of a car after a fair amount of usage unless adjustment is made. Adjust Track rod B.

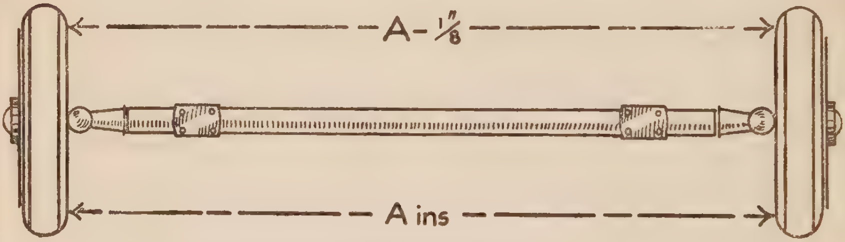


Fig. 360.—The correct amount of "toe-in."

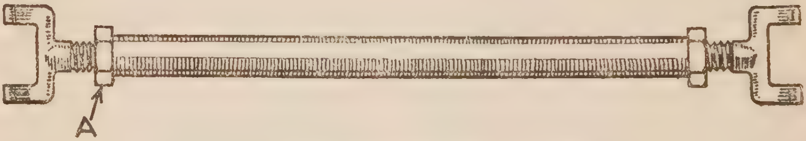


Fig. 361.—A diagrammatic view of Fig. 359.

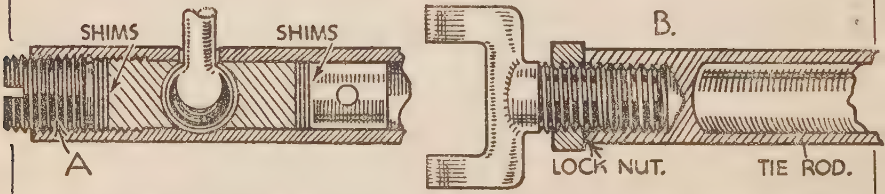

SHIMS
SHIMS
A
B.
LOCK NUT.
TIE ROD.

Fig. 362.—Showing how wear can be taken up in a ball-and-socket steering joint by fitting shims, and a simple method of varying the length of the rod.

little different but the result the same. Fig. 362 shows a typical arrangement. The ball is between two semi-spherical ended blocks, and there are shims at each end. The joint is locked by the screwed stop A with a split pin through the hole when the adjustment has been made. By taking shims from one end and putting them at the other end of the two spherical-recessed blocks the effective length of the tie-rod is altered and the adjustment for length of tie-rod is made.

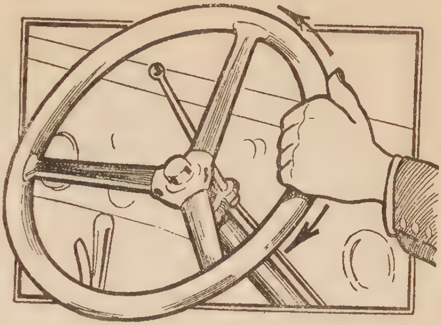


FIG. 364.—The amount of play in a steering wheel should not exceed 2 in. along the circumference.

The Steering-box.—There may be wear in the steering-box which is generally of the worm and quadrant type as diagrammatically presented in Fig. 363. The toothed quadrant A is fixed to the drop-arm B, and turned by the worm C, which is fixed to the steering column D. Since it is mostly in the straight-head position (approximately as shown), the wear comes on the middle teeth of the quadrant and excessive wear will mean backlash. The amount of slight movement between the teeth on the quadrant and the thread of the worm will be magnified, at the end E, of the drop-arm, by the amount the distance from the centre to the middle of any one of the teeth. A little wear will thus be seen to amount to a good deal of free movement at the end of the drop-arm. The drop-arm is fixed to the central shaft integral with the quadrant by splines shown in black. If the nut at the end of the shaft is removed and the drop-arm pulled off the quadrant can be moved round by the worm (by moving the steering wheel) so that in normal straight-ahead position new and unworn quadrant teeth engage with the worm and the drop-arm can then

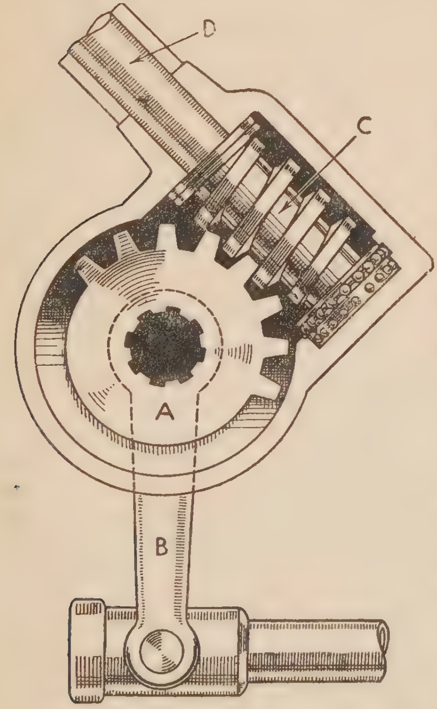
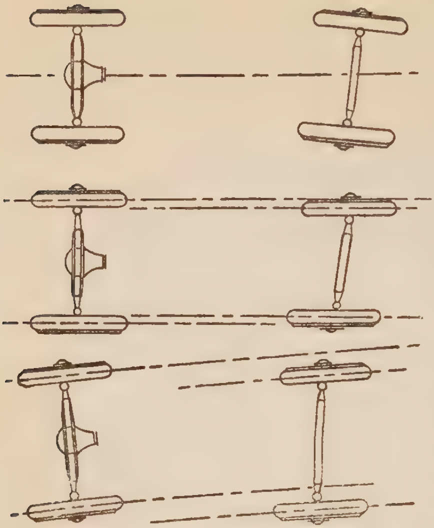


FIG. 363.—Wear in the steering box of the worm and quadrant type.



FIGS. 365 to 367.—(*Top*) Showing a weak off-side front spring. (*Centre*)—If the wheels are turned to steer straight, the back wheel will not follow the track of the front wheels. (*Bottom*)—A weak near-side rear spring.

be put on again. This adjustment can be made without dismantling the steering-box but it must be tried to see that the worm has full control of the quadrant on full lock in either direction. Some steering-gears have a full circle of teeth and thus offer more scope for more adjustments.

Wheel Alignment. — The steering will be affected if the road-wheels are out of alignment with each other. They should be tested by a line down each side when all wheels are in the straight-ahead position. Weak springs will put the axles out of line in some axles because the springs are pivoted at one end to the chassis, and if they become weak and lose their camber they lengthen the effective length from spring end to axle.

Fig. 365 shows the off-side front spring is weak. It is anchored at the front dumb-iron and has straightened out and brought the off-side end of the axle nearer the back. If the wheels are turned to go straight the back wheel will not follow the track of the front wheels (*see* Fig. 366). Each will follow a track just inside the tracks of the back wheels. The remedy is to have the spring set. If the spring is pivoted at the rear end and shackled at the front the opposite effect will be the result, but theresult will be the same. If a near back spring weakens on a car using an open cardan shaft with the spring pivoted at the front the result will be as in Fig. 367. To make the car go straight, the front wheels will have to be turned to the near side as shown, but the car will go crab fashion and will have four tracks, instead of two, as indicated by the dotted lines.

Where the back axle is driven by a propeller shaft in a torque tube built as part of the axle and anchored at its forward end in a spherical joint, the back axle cannot get out of square.

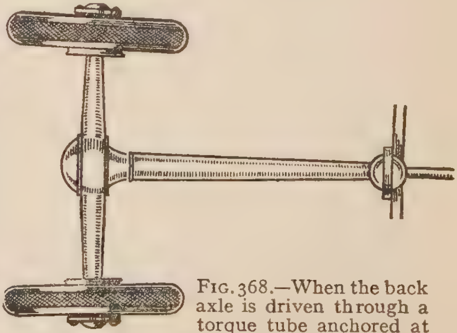


FIG. 368.—When the back axle is driven through a torque tube anchored at its forward end in a spherical joint, the back axle cannot get out of alignment.

Wheel Patter, Shimmy, and Wobble.—Of recent years trouble has arisen in the case of some cars by reason of the erratic behaviour of the front wheels, and the cause is not yet completely determined, even by car designers. Some good cars suffer. Others are immune.

Many car-owners have experienced the annoying and sometimes baffling trouble of wheel wobble, that defect in which the wheels get into a state of vibration from side to side. At low speeds they may deflect through a fairly wide angle. In the case of shimmy, the vibrations are more rapid and come on only at much higher speeds and are transmitted through the driver's steering-wheel to his hands. This movement of the wheel is dangerous, since at high speeds it may result in inability to steer a true course and an accident may occur. Patter is an entirely different matter. The wheels rise and fall alternately, due to the axle oscillating as a beam about its centre—one wheel up and the other wheel down. Patter never occurs in the case of cars with independently-sprung wheels, *i.e.* those in which each of the front wheels is controlled by a separate spring or a pair of parallel springs, the latter being transversely arranged, anchored at the centre, and free at the ends. Where this springing is adopted patter cannot occur. In patter one wheel jumps up first and the other follows as the axle oscillates about the centre.

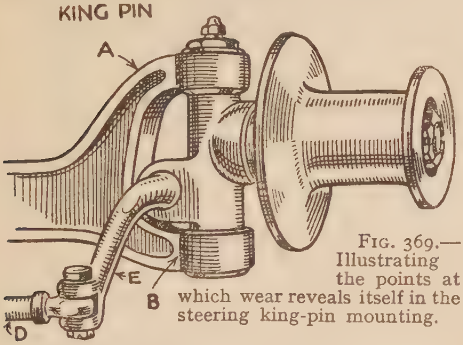


Fig. 369.—Illustrating the points at which wear reveals itself in the steering king-pin mounting.

Causes of Wheel Wobble.—Wobble can be caused by one or a combination of errors in lay-out, or condition. Since the centre about which the wheel revolves is outside the centre on which it steers—one being a nearly horizontal axis and the other a nearly vertical one—it follows that, if the two wheels were not linked together by the transverse tie-bar, each would have a tendency to turn on the vertical (steering) axis backwards, splaying the wheels out, as the car was pushed forward by the drive of the rear wheels. If there is any looseness in the steering-heads, and particularly in the joints of the transverse tie-rod which connects the two arms of the stub-axles, one wheel may meet an obstruction, move round the amount allowed by the looseness and then, coming up against the tie-rod, tend to push the other wheel. The reaction then takes place and the wheels are moved in the opposite direction. This may be the cause,

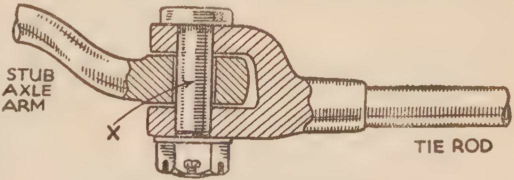


Fig. 370.—Points where looseness in the tie rod occurs in the case of knuckle joints.

or one element in a combination of causes, the others to be referred to later.

Loose Steering-head.—If there is a looseness at A and B (Fig. 369) in the king-pin, which has its bearing at the points shown, then the wheel can move the king-pin backwards and forwards, and the end of the steering-arm C will be moved a greater amount. It will push the tie-rod D through the steering-arm E, and the wheel will move some distance round before it affects the opposite wheel. But when it does begin to affect the other wheel it will be with a decided knock or impact, and the other wheel (probably with as loose parts as its fellow) will be forcibly thrown round. Since the movement of one wheel does not take place at the same time exactly as the other, an oscillation may be set up and the wheels will react like a pendulum, and a decided wobble will develop and will not stop till the speed of the car is much reduced. This wobble will be felt through the steering-gear and efforts to reduce it by manipulation of the steering-wheel may make matters worse. The obvious thing is to have the bearings of the steering-head (whether they are plain or ball or roller) adjusted so that there is only rotary movement.

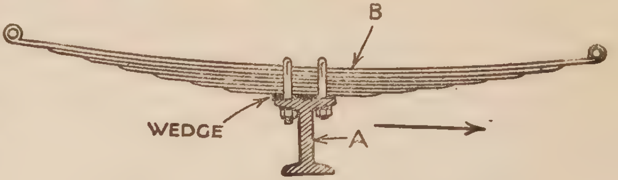


Fig. 372.—Incorrect "cant" of the springs can be corrected by fitting a wedge as shown above.

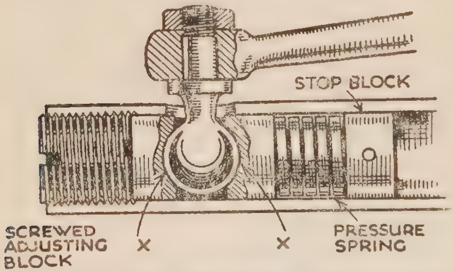


Fig. 371.—When ball and socket joints are used looseness is likely to occur at the points marked X, X.

The Tie-rod and Drag-link Joints.—The pins of the joints at the end of the tie-rod and at the end of the arm which connects the stub-axle to the drag-link and so to the depending lever of the steering-box should, also, if there is any play, be replaced by new pins fitted in the holes which have been reamered or lapped, for the holes wear oval (as do the pins) and a new king-pin and new knuckle-joint pins should be fitted of bigger size to suit the enlarged reamered holes. Where the tie-rod and drag-link have ball- and socket-joints, these are usually adjustable and they should be adjusted till there is no shake. Sometimes where the ball and socket is used the half socket is spring-loaded, and the spring weakens, allowing the joint to open slightly under pressure of the wheel meeting obstruction. This may start wobble and the remedy may be found in tightening up the spring or fitting a new one of stronger calibre. Fig. 370 shows looseness in the tie-rod where knuckle-joints are used and Fig. 371 where the ball-

and socket-joint is used. The looseness takes place at the points marked X. If the drag-link between the arm on the stub-axle of the right-hand wheel and the drop-arm of the steering-box, is loose at the joints, even if the tie-rod joints and the steering-head joints are good, the impact on one wheel may turn the other equally before the back-lash in the drag-link is taken up and wobble or shimmy may occur. A worn worm and quadrant in the steering-box may have the same effect even if all the other joints and the steering-head king-pin are in good condition.

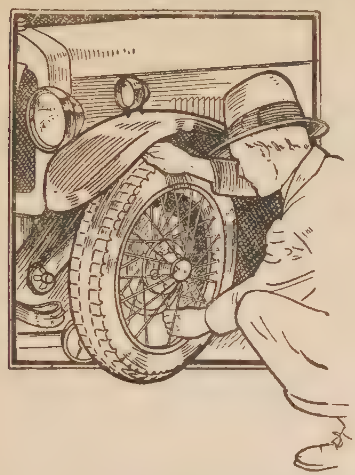


FIG. 373.—Wear in the king-pin bearings can be checked as shown here, by gripping the wheel at the top and bottom and then attempting to rock it.

Steering Dampers.—Sometimes wobble and shimmy can be stopped by the fitting of a steering damper. This is generally fitted between the tie-rod at its centre and the centre of the front axle and puts a drag on the transverse movement of the tie-rod and so stops the trouble. Patter may sometimes be cured by tightening the shock-absorbers at the axle ends between chassis and axle.

A wheel out of balance through being slightly buckled may set up both wobble and shimmy. In some cases shimmy or wobble can be cured by inclining the steering-heads more than allowed for by the designer by fitting hardwood wedges between axle and spring with the thick end of the wedge to the rear so tilting the heads backwards. The wedge should have an angle of not more than 4 degrees. The plan is shown in Fig. 372 where A is the axle and B the spring, and the vehicle is moving in the direction of the arrow.

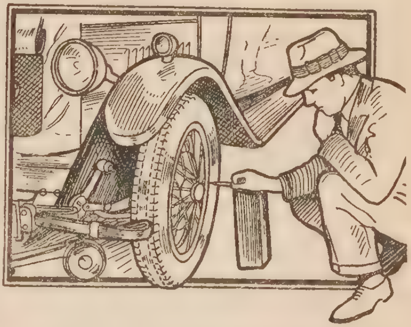


FIG. 374.—A simple method of testing a buckled wheel; the wheel is first jacked off the ground, and a pencil is held in a fixed position whilst the wheel is revolved.

A bent stub axle is a positive danger, and the entire axle assembly should immediately be replaced, for, apart from the question of the greatly increased and irregular tyre wear to which it gives rise, it is more than likely that the axle is cracked and therefore likely to break off whilst the car is in motion; a new stub axle assembly is not an expensive item, and the repair can quickly be effected.

Steering Adjustments — A steering gear should be adjusted so that there is practically no back-lash in the steering wheel itself. The adjustment in no instance should be so stiff that steering is difficult, otherwise the car will tend to "snake" down the road and it may even cause an accident. The steering should be correctly adjusted when the car can be controlled with two fingers of one hand. Naturally with so many systems in evidence it is impossible to deal in this small book with all of them. Only general information can be given. When making adjustments the front axle should be jacked off the ground and the steering gear operated over its full range of movement to ensure stiffness is not present. Starting at the road wheels there is the possibility of a front wheel bearing being loose. There is the pivot of the stub axle, any play of which in its bearings will involve back-lash at the wheel, as also will any wear in the pins and bushes of the tie-rod. Then, there are the two ends of the drag link to be considered, and after that play in the worm and worm-wheel, or screw and nut of the steering gear itself. Also if the steering box is not secured to the chassis or engine there will be a looseness at the wheel on account of the box moving instead of the gear. Another cause of back-lash is excessive wear on the rear shackle of the front springs, allowing the whole axle to sway when any movement is applied to the steering (*see* springs and shock absorbers). Wear in the bushes of the worm-wheel is sometimes the cause, and frequently the steering arm itself wears loose on its spindle. Every motor car is equipped with ball or roller bearings to its road wheel, and if looseness is traced to the wheel the only remedy is to replace the races complete.

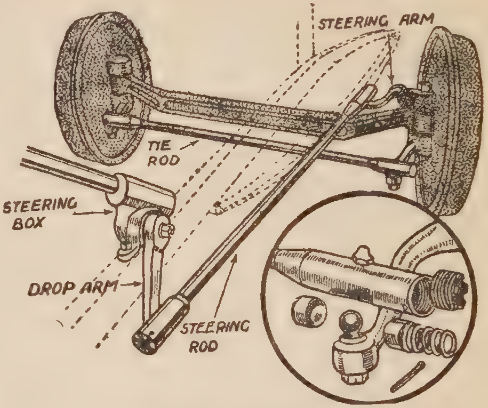


FIG. 375.—A Usual Steering Layout; (*inset*) Details of the Ball Joint.

If the king pins are worn, these too should be repaired. It will be found that apart from replacement the manufacturer has supplied a number of adjustments so that wear can be taken up. Wear between the worm and worm-wheel can usually be taken up in the following way. There are usually three positions of the wheel so that two new sets of teeth can be brought into place when wear takes place. Rattle in the steering column can usually be cured by slackening off the bolts securing the outer tube to the body, and tapping the cue upwards towards the steering wheel. (Refer to Figs. 375 and 376).

Adjusting End Play.—First unscrew the set pin and screw up the adjusting sleeve to take up the play. See that one of the slots in the sleeve is in line with the set pin, then tighten the set pin.

Examining a Steering Gear.—Starting at the road wheels the first thing to do is to jack up the front axle, then remove hub caps. This is necessary, because it is only with the hub caps removed that play between the wheel and hub and between stub axle pivots and bushes, can properly be located.

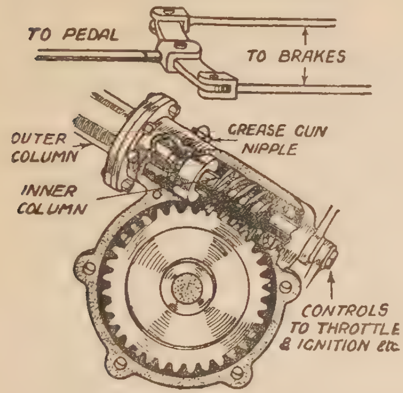


FIG. 376.—The Worm and Wheel Steering Box. There are usually three positions of the wheel, so that two new sets of teeth can be brought into play when wear takes place; the column can usually be adjusted for end play.

Test for play in the wheel hub by trying to rock the wheel vertically about the axle, watching the hub cap and end of the stub axle together, to note if there is any relative movement as between one and the other.

Next test for play between the bushes and steering pivot by seizing the end of the stub axle and attempting to lift that up and down.

Now turn attention to the tie-rod, and, getting an assistant to hold the end of one stub axle, try rocking the other in a horizontal direction to see if there is any play in the socket or jaw ends of the tie-rod.

The next operation is to remove the jack and allow the front wheels once more to rest upon the ground. Arrange for an assistant to take the wheel and move it to and fro, while the motion of the drag link is observed to see if there is any play in its ends.

Next, still working back from the road wheels, watch for play of the drop arm on its spindle.

Then, holding the drop arm, test the amount of play in the steering wheel, first in a horizontal direction, that is to say, by rotating it; that indicates the amount of play between the worm and wheel, or between the screw and nut as the case may be. Second, test for vertical play in the column by endeavouring to lift the wheel up and down. Most cases of that particularly aggravating trouble, wheel wobble, can be traced to abnormal play in the mechanism of the steering gear, and, as a general rule, a thorough overhaul of the steering gear and the elimination of any play will be found to effect a cure. There is, however, one point which should be borne in mind in this connection and that is the need for having the pressure in both front tyres equal. This is particularly essential in the case of balloon tyres. As a last resource, if careful and efficient adjustment for wear throughout the gear has been effected, if the front springs are in good order, with no excessive wear at the shackles, and if they are properly and tightly secured to the front axle, if the tyres are properly inflated both to the same pressure, and wobble still persists, then it may be advisable to fit one or other of the various steering dampers which are on the market.

It is rarely possible to machine the old parts of a steering gear in such a way as to take up the wear. New pivots, pins, and bushes are generally necessary.

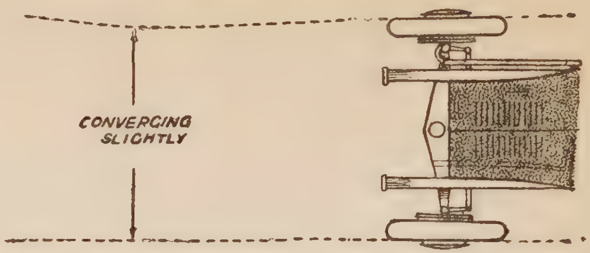


FIG. 377.—Diagram illustrating meaning of correct "Toeing-in."

Front Wheel Alignment. — One of the most important adjustments to ensure long tyre life is the proper alignment of the front wheels. If these should be out of alignment there will be strain on the whole of the steering, as well as rapid wear of the tyres. The front wheels should be towed in, that is to say, the distance between the front of the wheel should be less by about $\frac{3}{16}$th inch than the rear part of the front wheel. This adjustment can be carried out by means of the track-rod, and the dimensions can be checked by means of long straight edges, or the special wheel alignment gauges sold by most tyre manufacturers. The tyres provide a good index as to the need for realignment. If slight lips are formed on the tread the adjustments should be carried out without further delay. Before tampering with the steering adjustments in any way, follow the instruction book given with the car (*see* Fig. 377).

STEERING-WHEEL.—The large wheel at the top of the steering column by means of which the driver controls the steering of the car.

STEP CUT.—A term usually applied to the ends of some piston rings which are cut in zig-zag or step formation.
See *Plain cut.*

STEP-DOWN GEAR.—A train of gear wheels, the output speed of which is less than its input speed.

All car gears are examples of step-down gears, for they transmit to the road-wheels less revolutions per minute than are developed at the engine shaft.

STEP-UP GEAR.—A train of gear wheels, the output speed of which is greater than its input speed. The gear train driving a dynamo is often a good example of this.

The motor car rear wheels, when driven by the engine, is geared down, but when the car is *pushed*, with one of the gears engaged (an expedient sometimes resorted to when the engine refuses to start), it must be remembered that the rear wheels are driving the engine, and the engine is then geared up. Always engage second or even top gear when starting the engine by this method.

STORAGE BATTERY.—See *Accumulator.*

"STRAIGHT-RUN" PETROL.—A technical term applying to petrol distilled over directly from crude petroleum in order to distinguish it from petrols obtained by other means, as, for instance, by the process of "cracking."
See *Cracking.*

STRAIGHT-TOOTH BEVEL WHEEL.—A bevel wheel whose teeth are formed in straight lines. It constitutes the ordinary form of bevel wheel.

Straight Tooth Differential Gear.—A form of differential gear which has straight toothed pinions, instead of the bevel pinions of the type previously described. This type of gear acts on a very simple and very ingenious principle which is demonstrated by the diagram Fig. 378. C and D are two toothed racks which can move up and down vertically. They are in gear with the pinions E and F respectively. G is a frame which carries pinions E and F which can rotate in bearings in the frame at their ends, and frame G can be pulled along the racks by the ring H. Pinion E gears with rack C and pinion F gears with rack D and between the two racks the pinions gear with each other. Fig. 378 shows by means of a side view how the pinions gear with each other, and with the two racks.

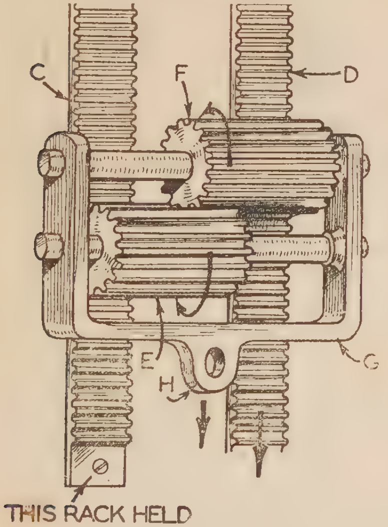


Fig. 378.—The above drawing illustrates the principle of the straight-toothed differential.

If we hold rack C and pull down the frame G the pinion E will be rotated in the direction of the arrow, because, being in gear with rack C, it will be rotated by the teeth. But since it is also in gear (in mesh) with pinion F it will drive F round in the contrary direction (as indicated by the arrow round F) and F being in gear with rack D will pull rack D down. It will come down at twice the speed of the frame G while rack C will remain stationary.

If we were to hold rack D and pull the frame G (which carries the pinions) we shall have rack C being pushed down by pinion E at twice the speed of the frame G. If we let both racks C and D free and pull frame G down the two pinions will try to move in the same direction as each other and roll down the racks. But being geared together they can only turn in opposite directions and so they will balance each other as to pull and will form a lock, pulling both racks (C and D) down together at the same speed as the frame G, and neither pinions or racks moving relatively to each other but all coming along together.

Differential Motion in a Circular Direction.—If we can curve racks C and D round so that they form toothed wheels and if we can carry the two intermeshing pinions E and F in a rotating cage so that they can rotate around the now-circular racks we can get this differential motion in a circular direction which is what we want for our back axle. This arrangement is shown in Figs. 379 and 380, where the same reference letters are used for the parts which perform the same functions as in the model (Fig. 378). C and D are racks formed into wheels at the ends of shafts A and B, which drive the road wheels and E and F are the pinions.

E is in gear with C and F is in gear with D; and E and F are in gear with each other. E and F are carried in a box G, which can rotate around shafts A and B (just as the frame G) (Fig. 378). could move along the racks C and D). This box G has on its outside a toothed bevel crown wheel H, which is driven by the bevel pinion J at the end of the shaft K in a bearing in the casing L which encloses the whole device. When shaft K is driven round by the engine its bevel pinion drives H round and as H is fixed to box G the latter goes round carrying with it the pinions E and F.

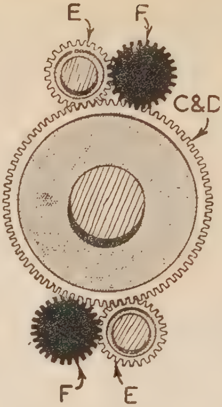


Fig. 380.—Diagrammatic representation of the principle of the assembly shown in Fig. 379

If the car is going in a straight line shafts A and B will have to rotate at the same speed and both will be driven round by reason of one being in gear with E and the other with F, and E and F being in gear with each other. But if we held shaft A, wheel C, which is on its end, would be held also. If now we drive H round the box G will rotate and E being in gear with C which is stationary will climb round C and so drive pinion F in the opposite direction and F will drive D round, and shaft B with it. B will be driven at twice the speed of the box G. We thus get the same differential motion as we did with the model Fig. 378, but in a rotary and continuous direction. If shaft A (or shaft B) is retarded (by being the shaft driving the car wheel on the inside of the curve) B will be correspondingly accelerated, but both will be driven by the engine.

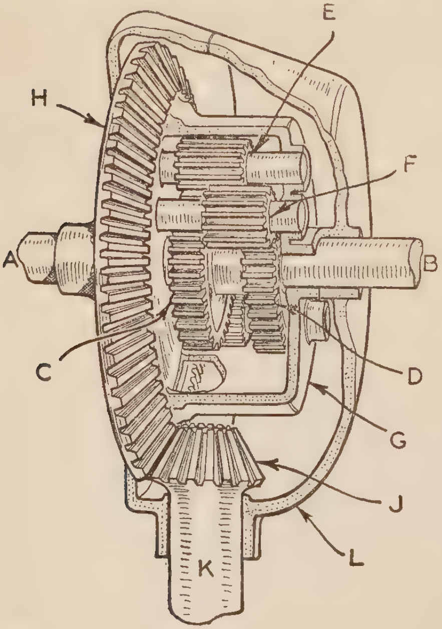


Fig. 379.—A perspective break-away view of the complete assembly.

The Two Types.—We thus get, without the use of bevel wheels, exactly the same differential motion as we get in the case of the bevel pinion type of differential gear previously described. The relative merits of the two types have been the subject of criticism. Both work equally well. It has been suggested that the bevel type puts an end strain on the wheels and pinions.

STRANDED CABLE.—Electrical cable made up of a number of wires twisted together. Used often in car-wiring circuits.

STREAMLINE.—Name given to a certain principle of a car's form or shape whereby when the car is in motion the wind pressure immediately in front of it is to a greater or less extent broken up, the wind dividing into two streams at the front of the car and flowing to the rear at each side of it.

STRESS. — In engineering language stress may be described as the state of a body under a load. Stress is customarily expressed in terms of tons or pounds per square inch.

STROKE.—The downward movement of the piston.

The distance which the piston travels during its upward or downward movement in the cylinder. The " stroke " of a piston is usually measured in millimetres.

STUB AXLE.—A short axle which is independently pivoted to the extremity of the main front-wheel axle, and upon which the steering-wheels are set.

STUD PIN.—See *Screw pin.*

SUCTION STROKE.—The downward stroke of the piston which sucks or draws the mixture of fuel vapour and air into the cylinder through the inlet valve.

SULPHATING.—Electrical term used to denote the formation of insoluble lead sulphate on the surface of the accumulator plates, thus interfering with the free charge and discharge of the cell.

The condition is usually the result of faulty treatment of the accumulator.

SULPHUR.—An element of well-known yellow appearance. In chemical combination it exists sometimes as an impurity in low-grade motor fuels and oils, its presence, except in very minute traces, being very deleterious to the well-being of the engine assembly.

SULPHURIC ACID.—Chemical formula: H_2SO_4. The acid used in the car battery. It is made by burning sulphur ores in contact with air and by combining the evolved gases with water.

Accumulator acid is made by diluting the purest sulphuric with water—two parts of the concentrated acid to eight parts of water, so that the specific gravity of the diluted acid is approximately 1·225.

SUMP.—The underpart of the engine crankcase which serves as a reservoir for the lubricating oil.

SUN-AND-PLANET GEAR.—See *Planetary gear.*

SUPERCHARGER.—An instrument which forces more fuel vapour and air into the cylinder than could be taken into it normally by the induction stroke of the piston. It comprises some type of blower device, which is driven off the engine and by means of which an extra amount of fuel mixture is forced into the cylinder.

Synonym: *Blower.*

SUPERCHARGING.—The system whereby an extra amount of fuel vapour and air is forced into the cylinder in order to give rise to increased power from the engine.

Synonym: *Forced induction.*

Supercharging implies an additional mechanical complication of the engine equipment, and it may also bring about overheating of the engine and bearings, unless the engine is specially designed for it. It would seem that supercharging is chiefly of use for racing purposes. Ordinary engines are equal to most ordinary touring conditions.

To the average motorist, supercharging is a very technical topic, fit only for the calculating minds of car designers and racing experts. It is popularly considered that one has to be greatly learned in the technics of engine design in order to obtain a complete grasp of this mysterious subject. Such ideas are quite mistaken ones, however. There is nothing very abstruse, or even difficult, about supercharging and its principles. For supercharging, or "forced induction," as it is sometimes termed, constitutes nothing more nor less than still another application of the gentle and age-old attempt to get "a quart into a pint pot."

It is quite obvious that, under ordinary conditions, only a maximum amount of petrol vapour and air can be crammed into each engine cylinder on the induction stroke of the pistons. If we plot a diagram or graph showing the *rate of increase in engine-power* against the *engine revolutions per minute*, we shall get a straight line up to a certain point. Thereafter, the straight line becomes a curve, and, very soon, it grows into a downward curve, showing that a falling-off in the rate of power-increase has taken place (*see* Fig. 384).

This diminution in the rate of power-increase is due to the fact that, as the engine speed creeps up, the speed of operation of the valves becomes higher. At a certain point in this speed-increase, however, it becomes impossible for the cylinders to obtain sufficient charges of the mixture owing to the very short instant of time during which the valves open for the induction of the mixture into the engine. Various mechanical devices such as very light valve gears, strong valve-springs, and valve-cams which are cut with very abrupt contours, have been tried in order to raise this maximum point. Nevertheless, sooner or later, as the engine-speed increases, the maximum point becomes operative and the engine, no longer being able to obtain sufficient charges of fuel, shows a steady and a progressive falling-away in power.

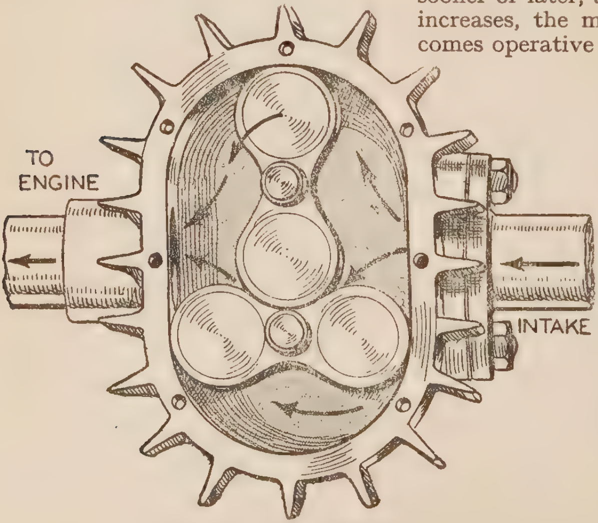


Fig. 381.—The Roots blower.

If, under these conditions, the engine speed was still further increased by some means or other, as might be the case in a racing car, a point would ultimately be reached at which the valve mechanism would no longer meet the demands of the

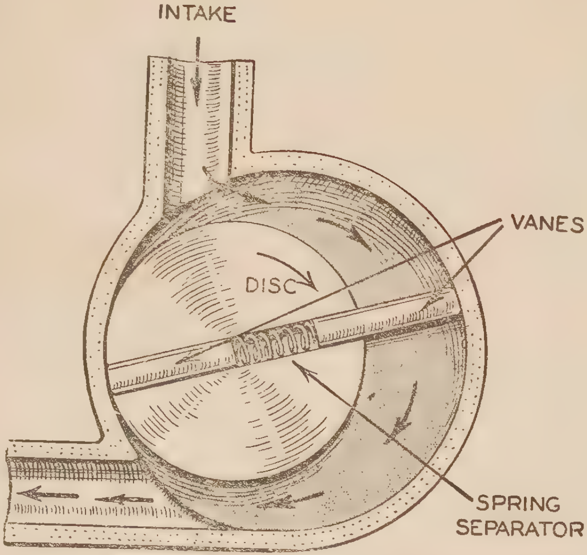

INTAKE
VANES
DISC
SPRING
SEPARATOR

Fig. 382.—The Zoller supercharger employs a pair of vanes separated by a spring. They are attached to, and rotated by, an eccentric.

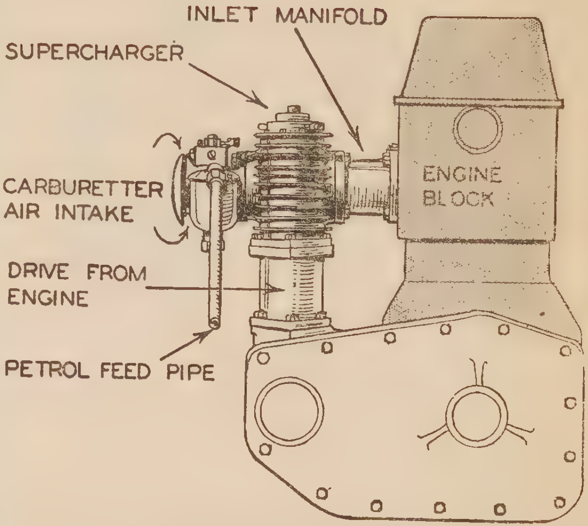

INLET MANIFOLD
SUPERCHARGER
ENGINE
BLOCK
CARBURETTER
AIR INTAKE
DRIVE FROM
ENGINE
PETROL FEED PIPE

Fig. 383.—How a supercharger is normally fitted to the engine.

engine. At this point all sorts of erratic engine-firing would manifest themselves, and the engine speed and power would, of course, instantly decrease. In the past the above scheme of things has very much militated against high engine speeds. Not only this, but it has also very definitely set a limit to the amount of power which can be developed by an engine of given cylinder capacity.

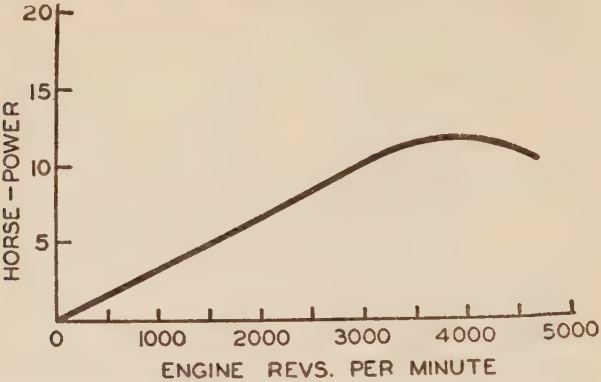


FIG. 384.—Graph showing how the power of an engine falls off after the attainment of maximum engine speed.

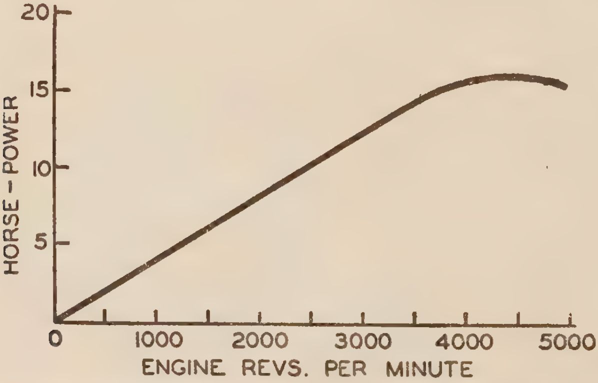


FIG. 385.—Graph showing how supercharging raises the point at which power begins to fall off.

Raising Limits of Engine Speed.—Supercharging, however, is a system of induction which raises very considerably these limits of engine speed and power development. At first introduced purely for racing purposes, it has been applied from time to time to ordinary road cars and with varying success. As a matter of fact, the application of supercharging to ordinary-purpose cars has been, and, indeed, still is a very much debated point.

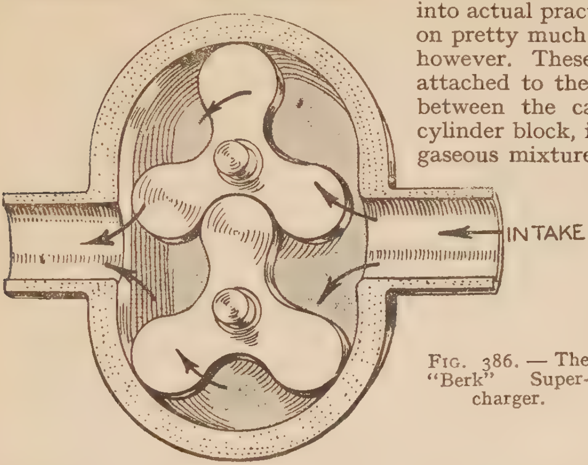


Fig. 386. — The "Berk" Supercharger.

Supercharging, or forced induction, applied to a car enables more of the mixture to be "packed" into the cylinders. Hence, the downward force of the explosion of the mixture after each ignition stroke is greater than would normally be the case. In this way, the point at which the rate of power-increase of the engine begins to fall away is very considerably raised, as will be seen by comparing Figs. 384 and 385.

A good system of supercharging will increase engine speed and the consequent power by about 15 per cent. In some instances a 20 per cent increase can be obtained, but generally a 15 per cent increase in engine speed represents good work.

A supercharger is merely a pump, usually run from the engine, by means of which the mixture is actually forced into the cylinders. There are quite a number of different superchargers which have been put into actual practice. They all work on pretty much the same principle, however. These superchargers are attached to the car engine usually between the carburettor and the cylinder block, in order that all the gaseous mixture may pass through the devices before reaching the engine.

Types of Blowers.—Perhaps the best known of all superchargers is the "Root's" blower. This as will be seen from Fig. 381 comprises a pair of "8"-section vanes or paddles, geared together, which rotate at high speed within a gas-tight metal chamber. The "Berk" supercharger, Fig. 386, is a similar device but here each revolving vane has three arms instead of two as in the case of the Root's instrument.

In the "Zoller" supercharger, Fig. 382, a later device, a pair of circular vanes, spring-separated, are employed; whilst in still another instrument, the "Cozette" blower, Fig. 387, a circular rotor is made to

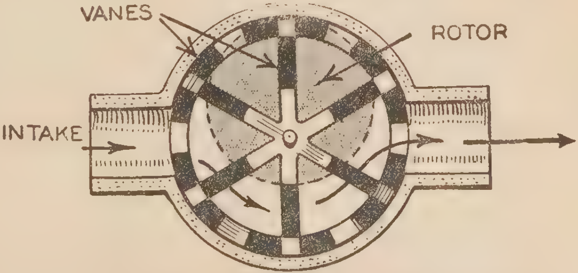


Fig. 387.—The Cozette Blower. An inner Rotor revolves at the same speed as the outer revolving vanes.

revolve within a system of rotating vanes.

All these supercharging devices have their own individual advantages and disadvantages. The Root's blower, for instance, is perhaps the most fool-proof of the lot, whilst, on the other hand, the neat little Cozette device is the most silent of them all.

Now, at this point, the reader may justifiably be inclined to remark: "Why not use cylinders of larger capacity to obtain the desired engine power instead of going to the trouble of supercharging cylinders of smaller size?"

It is a very pointed query, and, indeed, there have been some technicians who have held the opinion that even sometimes, for racing cars, supercharging is hardly worth while, in view of the extra complexity which it adds to the engine assembly. Nevertheless, in order to deal with the above query, let us regard the matter in the following light.

The Effect on Valve-gear.—If we wish to obtain high power output from an engine working at high speeds, we have already seen that specially-designed valve gear to give very rapid opening and closing of the valve ports must be used. Now, from an ordinary viewpoint this type of valve gear is decidedly bad. Exceedingly rapid valve operation gives rise to noise and to excessive wear. Also, this valve gear brings in its train high fuel consumption and bad pulling at low engine speeds. All these factors made such "high-speed" valves very objectionable for normal use.

If, however, a car is fitted with a supercharging device which only comes into action after, say, 2,500 r.p.m. have been attained, it would not be necessary to equip the car with such a valve system. A more normal system of valves could be employed. Then, when at about 2,500 r.p.m. the valves ceased to operate efficiently, a touch of a lever could bring the supercharging device into operation, thus imparting to the engine a fresh lease of life.

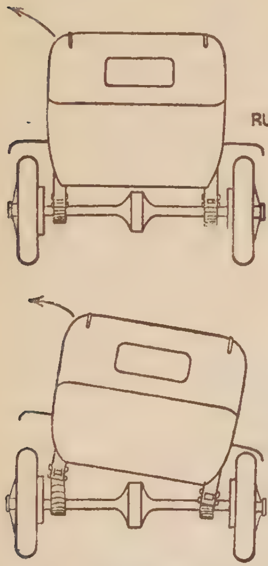
It is only in this way that supercharging could be applied really satisfactorily to ordinary cars, as indeed, it has been done in the past.

In racing engine design the cylinders are often supercharged at all speeds. However, in order to effect this satisfactorily, the cylinders have to be given an extra compression space, otherwise knocking would occur. The supercharger is driven off the engine. This absorbs a certain amount of engine power and, consequently, an increased fuel consumption results. However, in a racing car, where almost everything is subservient to high-power output and speed, the increased fuel consumption consequent upon the use of a supercharging system is of no consequence at all.

Whether or not the employment of some system of supercharging on touring cars will become a feature of future design and practice is matter upon which technical opinion is very greatly divided at the present day. It must be remembered that efficient supercharging makes not merely for increased speed but also for great power. Increased speed is little wanted for the average touring or family car. Increased power, however, is often desirable for such cars.

SURFACE CARBURETTOR.—An obsolete form of carburetter in which the petrol supply for the engine was obtained by means of a current of air sweeping over the surface of the liquid fuel contained in a metal chamber.

SUSPENSION SYSTEMS.—There are probably very few motorists who fully realise the importance of maintaining the suspension system in its most efficient state, and the fact that correct adjustment of the road springs and shock absorbers makes for longer life of the car is overlooked. It is fairly obvious that correct setting of the shock absorbers increases riding comfort, but that it increases the possible speed and safety of the car is not so evident. The importance of shock absorbers when cornering is shown by the two sketches in Figs. 388 and 389, the car shown below is not provided with shock absorbers, whilst that shown above is, but they are too tightly set. In the first case the car "heels-over" due to the off-side springs flattening out too easily when the weight of the car is thrown on to them by centrifugal force. When the suspension is too "hard," as represented by the second example, the springs do not "give" sufficiently and the car, therefore, tends to overturn when centrifugal force comes into play.



Figs. 388 and 389.—Two exaggerated diagrams showing two cars taking left-hand bends at speed. The car below is not fitted with shock absorbers, and that above has shock absorbers which are set much too tightly.

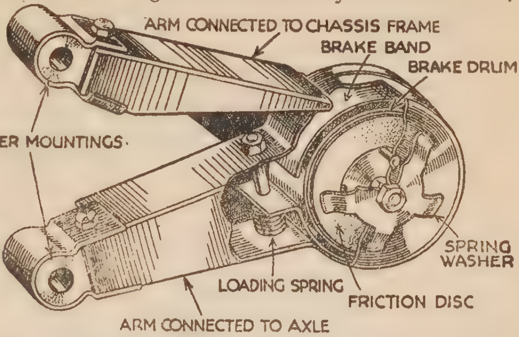


Fig. 390.—This cut-away drawing shows a shock absorber of usual type, the various parts being marked.

There is obviously an average setting somewhere between those of the two examples given, and with this there would be no tendency for the car to overturn, nor to sway over to an uncomfortable angle. When the springs become very soft—and shock absorbers are either not fitted, or they are incorrectly adjusted—there is even a possibility of the "outside" (on a curve) mudguards actually touching the tyres and rubbing.

It is not only in cornering that correct tension of the suspension system is important, for it matters quite as much when following a straight path. If the suspension is too "soft" the car takes on a wavy motion every time a slight bump is negotiated whilst anything other than very slow driving on roughish roads gives one a literal "pain in the neck" due to the most unpleasant bouncing of the car. On the other hand, if the springs are too hard, driving is distinctly unpleasant at low speeds since every irregularity in the road surface is transmitted directly to the chassis.

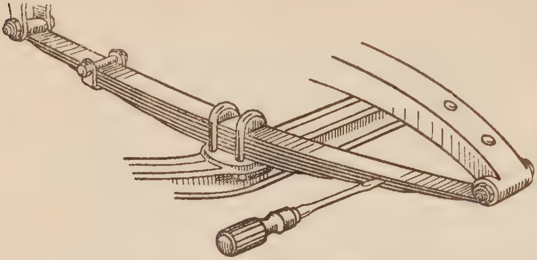


Fig. 391.—One method of lubricating leaf springs is to remove the clips, prise the leaves apart with a screwdriver and then apply a little graphite grease on the blade of an old table-knife.

In racing and super-sports cars it is usual to make the suspension distinctly hard so that the machine is most suitable for its normal purpose, and anyone who has driven a car of this kind through the streets knows how unpleasant it can be. Normal touring cars have to traverse practically every kind of road surface, and at a variety of speeds, therefore, some compromise must be made in adjusting the suspension.

As a point of interest, however, and to show how important the question of suspension is considered to be by car designers, it might be mentioned that there are now a few high-class cars which are provided with a shock-absorber adjusting knob, which can be reached from the driving seat. By this means the "hardness" or "softness" of the suspension can be varied while the car is travelling.

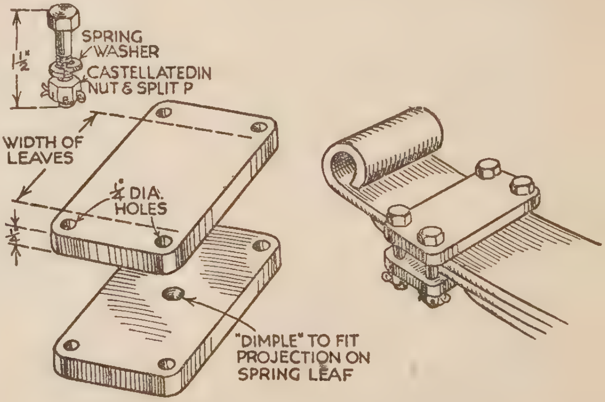


Fig. 392.—The "hardness" of the springs can be increased by fitting clips, like those shown above, at each end.

Adjusting the Shock Absorbers.—The problem which the average driver comes up against concerns the method of setting the shock absorbers. When the car is new, the correct settings will have been made and, therefore, no alteration should normally be required during the first 1,000 miles or so. After that, it will almost certainly be desirable to give all the shock-absorber adjusting nuts about one half-turn, the actual movement required depending upon the type of units fitted. In nearly every instance, it will be found best to tighten each adjusting nut by the same amount, but the resistance offered by the various shock absorbers can be compared by standing on each dumb iron in turn and swaying the car; the resistance to movement in each case should be the same. The method of tightening the adjusting device varies slightly with different makes, but a common one is illustrated in Fig. 390 where the cut-away view also shows how the absorber works. Tightening the adjusting nut increases the frictional resistance between two friction discs, and also between the discs and the edge of the brake-drum. As the friction is increased the "damping" effect exerted on the up-and-down movement of the road springs is made greater. The nut should be tightened until the body of the car has no tendency to follow a wavy path after a slight pot-hole or bump has been hit. At the same time, it should not be so tight that the car feels, when travelling slowly over cobbles or village streets, as if the axles were attached directly to the chassis, no springs being used.

Attention to the Springs.—It is important to remember that shock absorbers are complementary to the springs, and that no adjustment can give the desired effect if the springs themselves are not in good condition. For example, if the springs have become rusty they will not work freely since the separate leaves will have difficulty in sliding along each other as they must do when they flatten out. There are some drivers who think that it is quite a good idea (when shock absorbers are not fitted), to allow the springs to rust so that their action will be "hardened." This system is distinctly bad, however, because it increases the danger of breakage and gives an effect which is entirely out of control. The springs should always be lubricated freely if they are to give the most satisfactory service, and this can be done in two or three different ways. One is to dismantle them and smear each leaf on both sides with graphite grease, and then reassemble; another is to prise the leaves apart by means of a screwdriver (*see* Fig. 391), and then insert grease by means of a knife blade; a third is to use a special leaf-spring lubricator, such as that illustrated on another page of this volume, and yet another is to spray the springs with some form of penetrating oil.

The latter is the easiest, but its effect is perhaps not so long-lived, and therefore, it must be repeated at more frequent intervals. Any of the well-known penetrating oils can be used, but one containing colloidal graphite has special advantages. The oil can be applied with a force-feed oil can, a petrol syringe or a brush, but in any case it is better to jack up the *chassis* of the car before the application; this allows the leaves to open very slightly and gives the lubricant a better chance to penetrate. A good alternative to the oil mentioned above is a mixture of engine oil and paraffin, and this is best brushed on to the leaves.

"Hardening" the Suspension.—When it is desired to "harden" the suspension without going to the expense of fitting shock absorbers an excellent and well-tried method is to bind the leaf springs tightly with a long piece of lamp wick. Before this is wound on the leaves should be thoroughly lubricated and then, after winding, the wick should be liberally soaked with oil. This method has the further advantage of keeping the springs supple and properly lubricated for long periods. A few years ago it was fairly common practice to treat the springs of fast sports cars in this way, and the writer has used the idea with success on a number of occasions.

Another method of making the springs less resilient is to fit clips of the type shown in Fig. 392. These simply consist of two steel plates which fit over the leaves, and they are held together by means of four short bolts. The clips must not be able to move laterally along the springs, and any such tendency can be prevented by using them in place of the normal strip-steel clips which are fixed in place by a "pimple" formed on the spring leaf, this fitting into a "dimple" in the clip, or *vice versa*. A suitable "dimple" can be made in one face of the new clip by drilling a small, shallow hole.

Increasing Spring Tension.—Whilst on this subject, it should be mentioned that there are special coil springs on the market which can be used to augment the action of the normal springs; these are fitted between the upper surface of the spring and the chassis, as shown in Fig. 393. The coil springs are not particularly expensive, and in many cases they will save the expense of removing the leaf springs and having them re-tempered and "set-up" to the correct camber. At the same time the latter procedure is always recommended when the springs have flattened appreciably or become very soft.

Very often it will be found that the near-side springs have flattened, although the off-side ones are practically as new; this is due to more weight being thrown on to them by the road camber. When the springs show signs of flattening they should be removed as soon as possible and attended to. The method of removal is simple enough, the process being as follows: First raise the appropriate "corner" of the car by placing the jack under the chassis—it is useless to place the jack under the axle as when changing a wheel, etc., because the spring would then take the weight. Next remove the wheel and slack off the U-bolts by means of which the spring is anchored to the axle, and then take out the shackle bolts at each end of the spring. The idea will be more easily understood by referring to Fig. 394.

Re-tempering and Setting up.—After the springs have been removed they can be sent to the makers, or to one of the many firms specialising in springs repairs, to be tempered and re-set. It might be mentioned, however, that, in the case of an old car, when it is not desired to go to the expense of proper repairs, some improvement can be obtained by dismantling the spring leaves and hardening each one separately by hammering. The method is to lay the leaves on a hard, flat surface with the concave side upwards, and strike with a heavy hammer, working from the centre of the leaf toward each end. This will not produce ideal results, but it will give some improvement, since the hammering will tend to harden

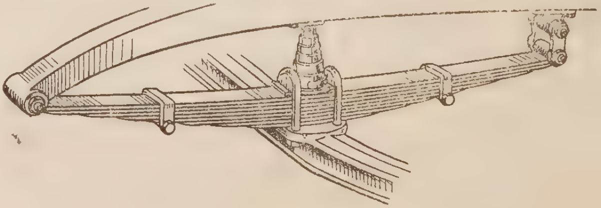


FIG. 393.—When the leaf springs have become soft their action can be improved by fitting special coil springs as shown.

the steel in addition to causing it to bend a little more in the direction of the original curve.

S.W.G.—The abbreviation for "British Standard Wire Gauge,"—the legal British standard wire gauge.

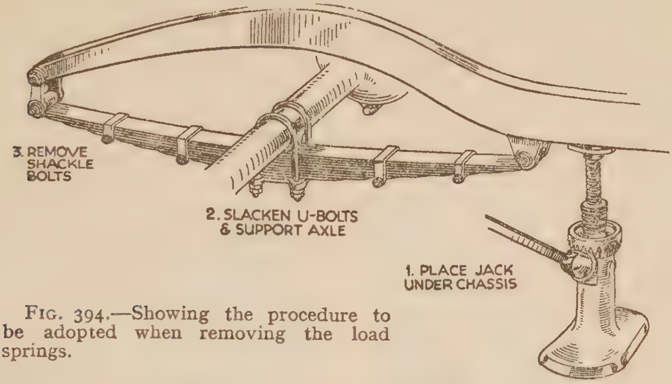

3. REMOVE SHACKLE BOLTS
2. SLACKEN U-BOLTS & SUPPORT AXLE
1. PLACE JACK UNDER CHASSIS

Fig. 394.—Showing the procedure to be adopted when removing the load springs.

SWITCH.—A device for opening and closing an electric circuit in a ready and convenient manner. Electrical switches are of many varying types and patterns.

T

TACHEOMETER (TACHOMETER).—A device for measuring the revolution speed of any rotating part.

From the Greek, *Tachos*, speed.

TAG.—A small connector fixed to the end of a wire or cable by means of which the latter is conveniently secured to a terminal.

Example: The end-tags on the high-tension wire which attach it to the sparking-plug terminal.

TAIL LAMP.—See *Rear light.*

TANGENT.—The name given to a line which touches the circumference of a circle but does not cut through it.

From the Latin, *Tangere*, to touch.

TANK INDICATOR.—See *Fuel gauge.*

TAP.—A small steel shaft, suitably grooved on the outside, which is used to cut threads on the inside of an aperture or piece of work, the tap being supported in a special handle known as *Tap wrench.*

See *Die.*

TAPER PIN.—See *Feather.*

TAPPET.—A part of the valve mechanism of the internal-combustion engine comprising a steel rod which works in a bearing, and which serves to transmit the "lift" motion of the valve cams to the valves, so that they are regularly opened.

TAPPET CLATTER.—An expression which denotes the characteristic sound produced by a valve between whose stem and tappet there is too much space or clearance. A light tapping sound is thus set up when the valve is operating.

TAPPET CLEARANCE. — A minute space provided between the end of the valve stem and its tappet in order to allow for the expansion of the valve stem when heated. The clearance is not more than a few thousandths of an inch.

TAPPET GEAR. — The arrangement of tappets for operating the valves of the engine. The principle is a very old one. It was originally employed on steam engines of the oscillating beam type. (See *Valves.*)

TAP WRENCH.—See *Tap.*

TEMPERATURE.—See *Heat.*

TEMPERING.—The art of bringing to a correct degree of hardness and elasticity. Steel, for instance, before it is fit for many uses, has to be very carefully " tempered " by means of one or more heat-treatments.

TENSILE STRENGTH. — See *Tension.*

TENSION.—The state of being stretched. Tension may also be described as the condition of a body when it is subjected to a strain in the direction of its length, the body tending to be pulled out or elongated.

The resistance of a material to tension, that is to say to forces which tend to pull it apart, is known as its *tensile strength,* which is a very important factor to be noted among the properties of various constructional materials for automobile engineering and other purposes.

TERMINAL.—An electrical conductor, usually of special shape and heavily made, from or to which an electrical connection is made, as, for instance, the terminals of an accumulator or the sparking-plug terminal.

Generally, terminals are made of brass, this metal being found to have the most serviceable qualities for the purpose.

TETRAETHYL LEAD.—Another name (and an incorrect one) for lead tetraethyl, which see.

THERMAL EFFICIENCY.—The ratio of heat converted into work to the total amount of heat produced by the engine.

If all the heat produced by the combustion of the fuel could be converted into useful work, the engine would be practically a perfect one, and it would have a thermal efficiency of 87 per cent. Needless to say, no such theoretically-perfect engine exists, few engines having a thermal efficiency of more than 20 per cent.

THERMOSTAT.—A device which maintains a liquid at a constant temperature. A variation of it is sometimes applied to the cooling system of an engine in order to maintain the water therein at a constant temperature under varying conditions of engine operation.

THERMO-SYPHON CIRCULATION.—Name used to describe a water-cooling system for internal-combustion engines. This system depends upon the principle of hot water being lighter than cold water, and thereby rising to the highest level of a water-circulation system, thus displacing the colder water. In this manner a continuous circulatory movement of the water is obtained.

See *Convection, Pump circulation.*

THIOPHENE.—Chemical formula : C_4H_4S. A colourless liquid occurring in commercial benzole. It contains sulphur, and therefore, like all sulphur compounds, its presence is undesirable. Fortunately, it is only contained in benzole to the extent of about 0·5 per cent.

THREE-QUARTER ELLIPTIC SPRING.—A type of car spring which comprises a half-elliptic spring attached at one end to a short curved leaf-spring, the whole spring assembly thus created taking the shape of three-quarters of an ellipse.

THREE-QUARTER FLOATING AXLE.—A type of back-axle construction in which some of the rear weight of the car is supported by the axle casing. The rest of the weight is borne by the axle shafts.

THROTTLE.—Name given to the valve which controls the entry of the gaseous mixture into the cylinders.

THRUST BEARING.—Name given to a bearing which takes the end thrust or pressure exerted by a rotating shaft along its length.

THRUST PIN.—Name given to a portion of many clutch mechanisms comprising a metal rod or plunger which relieves the pressure of the plate springs by movement transmitted to it from the clutch-pedal and so enables the clutch to be " withdrawn."

TIE BAR.—See *Tie rod.*

TIE ROD.—Term usually applied to a metal rod which gives support to the road axles and which also assists in maintaining the alignment of the wheels, for which purpose it is generally made adjustable.

TILLER.—The steering-handle or lever fitted to the earliest cars before the advent of the steering-wheel.

TIMER.—Name applied to certain types of revolving make-and-breaks in car ignition systems.

TIMING CHAIN.—The small metal chain actuating the valve-timing gear of an engine.

TIMING GEAR.—A train of wheels attached to the engine, so devised that they operate cams, thereby causing the inlet and exhaust valves to open and close in correct sequence.

TINFOIL.—Thin sheets of metal, mainly of tin. They form an important part of the construction of coil and magneto condensers. Commercial tinfoil is generally about 2/1,000th of an inch in thickness.

TITANIUM.—A hard, steel-grey metal of high melting-point. Added to steel in small quantities (up to 1 per cent) it improves the durability and toughness of the product.

Titanium steels have been used from time to time in car construction.

" TOE-IN."—Term used to denote the slight inclination towards each other which the opposite road-wheels of a car are given, the front portions of the wheels being nearer to each other by about ⅜ inch than the back portions of the wheels. This adjustment is necessary owing to the fact that when the car is travelling under load the road-wheels tend to splay out, that is, to incline outwards slightly, thus setting up heavy wear on the tyre treads. (See *Steering*.)

TOGGLE.—A short bar of rectangular cross-section, with tapers from its centre to both ends.

TOLERANCE.—In automobile and other constructional engineering, the " tolerance " of a part is the variation in size from the normal which may be permitted. In some engine parts the tolerance allowed is very minute, amounting, at the most, to one or two thousandths of an inch.

TOLUENE.—Chemical formula: $C_6H_5.CH_3$. Methyl Benzene. A hydrocarbon liquid occurring in commercial benzole. Boiling point, 110°C.

TON-MILES.—An expression which attempts to indicate the efficiency of an engine as regards fuel consumption. It is generally only applicable to heavy vehicles.

The ton-miles per gallon of a petrol vehicle is ascertained by multiplying the weight of the vehicle by its consumption of fuel in miles per gallon.

TOP DEAD CENTRE.—Name descriptive of the position of the piston when it reaches the top of its travel within the cylinder and is about to begin its downward journey.

TORQUE.—Literally, a twisting effect. The turning tendency of a shaft.

In a car engine torque is supplied to the crankshaft by the downward movements of the pistons. From thence torque is set up in the road-wheels of the car.

The crankshaft torque is constantly varying. At any moment its measure depends upon the position of the crank and the obliquity of the connecting-rod at that particular instant.

TORQUE ROD.—A metal bar or rod so connected that it resists the torque or twisting tendency of any part or member. Torque rods are, by way of example, connected to the back-axles of cars to prevent them from twisting round.

TORQUE STAY.—See *Torque rod.*

TORQUE TUBE.—A tube containing the propeller shaft which is connected at one end to the back-axle assembly of the car and at the opposite end to a movable joint. Its function is to prevent the torque or turning power of the engine from tending to twist the car round its axis.

In theory it is a method of applying the principle of the torque stay to the back-axle of the car.

T.P.I.—An abbreviation referring to screw-threads and signifying " Threads per inch."

TRACK MEASUREMENT.—Used in reference to cars, the term denotes the distance between the middle line of one road-wheel and the middle line of the opposite wheel. Practically speaking, it is the separation distance of the car road-wheels.

This measurement is also referred to as the " wheel gauge."

TRACTIVE COEFFICIENT.—Technical term indicating the power required per unit of mass to move a car or other vehicle at constant velocity over a given surface. It is usually expressed in lbs. per ton.

TRACTIVE RESISTANCE.—The resistance of a surface to traction or drawing along it.

See *Road resistance.*

TRAILER.—Name attached to a vehicle which can be attached to the rear of a car and thus drawn by it.

TRANSFER.—A sheet of paper or other material embodying a specially prepared surface containing a design or lettering which, by suitable treatment, can be transferred from it to another surface. In the past much ornamental lettering and other devices have been produced by the method of transferring.

TRANSFER PAPER.—Term usually referring in engineering practice to stout, semi-transparent paper which can be laid over a drawing or design, thus permitting a pencil or ink tracing of the latter to be drawn upon its surface.

TRANSMISSION.—The mechanism whereby the motive power of the engine is transmitted to the road-wheels of the car.

The term is often more loosely applied to some local or particular portion of the transmission system, as, for example, the propeller shaft.

TRANSMISSION KNOCK.—A peculiar knocking sound emanating from some portion of the power transmission system of a car. It may often be located at the universal joint at which place it is due to wear of the parts. Wear inside the gearbox may also set up a similar knock.

TRANSMISSION SHAFT.—The shaft which transmits power from the gearbox to the back-axle of a car.

Synonyms: *Arbor shaft, Propeller shaft.*

TREAD.—Applied to tyres, this term denotes the grooved or otherwise pattened surface of the outer cover which makes contact with the road surface. It is, as it were, the portion of the tyre which the car treads upon.

TREMBLER.—Name applied to the little steel spring which serves to operate the make-and-break contact device on an induction coil.

TRIP MOVEMENT. — Name usually applied to the mileage-indicating portion of a speedometer which can be set at zero at will, and which thus serves to indicate the total mileage of a journey.

TROUGH LUBRICATION.—A system of engine lubrication in which the oil is contained in troughs placed under the big ends of the engine. Oil is splashed around by the motion of the big ends in the troughs, and a mechanical device is fitted whereby the oil troughs can be raised nearer to the big ends as the throttle-opening of the engine increases, thus providing for a greater oil-splash when the engine is running at higher speeds or under greater loads.

TRUNNION.—A term applied to a bearing which carries an oscillating and not a completely rotating shaft.

TUBE FIRING. — See *Tube ignition.*

TUBE IGNITION.—An early system of firing the explosive mixture by means of a small platinum tube which was heated to redness. The system is now entirely obsolete.

TUBULAR SPOKES.—Road-wheel spokes which are not solid, but which consist of tubes more or less in imitation of solid spokes. Such spokes give lightness to the wheel without taking away much of its strength.

TUMBLER SWITCH.—The pattern of electrical switch which is usually employed on car circuits. It consists of an insulated base upon which is mounted a central tumbling or contact-making member operated by a knob which projects through a dust-tight cover.

Tumbler switches are very durable in action and seldom give trouble.

TUNDISH.—See *Funnel.*

TUNGSTEN.—A hard, grey, semi-precious metal which, on account of its extremely high melting-point (approximately 3,300° C.) is used to tip the contact-breakers of magnetos and induction coils, and also as a filament metal for electric bulbs.

Alloyed with steels, tungsten very considerably increases their hardness.

From the Swedish : *Tung*, heavy ; *Sten,* stone.

TURBULENCE.—Technical term used to denote the whirling condition of the combustible mixture of fuel vapour and air as it enters the cylinder. This condition of turbulence is necessary in order that the vapour and air may be mixed thoroughly.

TURNING CIRCLE.—The circle which a car describes when turning with its steering-wheel fully " locked."

The longer the wheelbase of a car, the greater its turning circle.

TURNING MOVEMENT UNIT—The amount of torque which is created by a force of 1 lb. operating at a radius of 1 foot from the centre of the rotating body.

TWIST DRILL.—A drill which contains two long, spiral grooves on the steel shaft from which it is formed.

TWO-STROKE CYCLE.—Name given to an internal-combustion engine cycle in which the power impulse on the piston occurs at every alternate stroke of the latter, the engine combining compression of the mixture with an explosion at every revolution of the crankshaft.

The two-stroke engine eliminates the use of valves and timing gears, and for this reason tends to simplicity. Although it is, for a variety of reasons, not employed for car engines, the two-stroke engine is used on motor-cycles, and in some marine and high-power stationary engines.

The two-stroke engine of the present day was first developed by Sir Dugald Clerk, in 1881.

TYRES, REPAIRING.—Though the modern tyre gives very little trouble, punctures do occur, usually at the most inopportune moments. If it is a rear tyre which is affected, the car will usually develop a swaying motion until the tyre is fully deflated. If this motion is experienced the cause should at once be investigated. The tube will be seriously damaged if the car is run after all the air has escaped. When a front tyre becomes deflated the steering will " pull " in the direction of affected wheel.

To fit the spare wheel, it is first necessary to jack up the car. Nothing is more annoying than to find the jack rusty and stiff with lack of use, when a wheel has to be changed. This tool should be examined at intervals and cleaned and oiled. Place the jack under the axle, as near to the wheel as possible, and see that it is in such a position that the handle can be operated without difficulty. Take care that it does not foul any brake or other connection. Now wind the handle until the wheel is eased a little from the road, but do not lift it clear. The wheel nuts can then be slacked off with ease, as the wheel will not turn. Complete the lifting action until the tyre is well clear of the road when the wheel nuts can be removed and the wheel taken off the hub. The spare wheel should not be taken off the bracket and the punctured one fitted to it immediately. This prevents it being inadvertently left on the road. (This has been known to happen !) Fit the spare to the hub and replace the wheel nuts. These should be tightened up evenly all round, otherwise the wheel may not " sit " firmly on the hub. Let down the jack and replace it in the car, finally tightening the wheel nuts again. It should be noted that on many cars the nuts on one side have a right hand, and on the other side a left hand thread. When overhauling a car it is useful to remove and clean the wheel nuts, oiling them well before they are replaced. This prevents them rusting on to the stud and thus becoming difficult to remove. The spare should always be attended to, when the other tyres have their pressure checked so as to have it ready for service when required.

Repairs.—On returning home the puncture must be repaired ; this is a simple and satisfactory operation if it is carried out in the correct manner. The modern straight-sided tyre on a well-base rim requires no force or great strength to remove it. In fact, with a private car, two small levers some six or eight inches long are all that is required. First remove the valve cap and also the lock nut. The valve inside should now be screwed out of the stem, using the slotted end of the small cap for this purpose. The tyre lever can now be inserted between the tyre and the rim near the valve, and pressure exerted on the free end. Bring this free end over and pass it behind a spoke. If the car has disc wheels the lever will have to be held in position. Now go round the tyre and, with the fingers, pinch the edges of it together so that they will both slip into the well of the rim. Having done this, it should be simple to remove one side with the other tyre lever. Should it be found that force is required to bring the tyre over the rim, the trouble is that the edges are not right down in the rim well.

Testing the Tube.—After removing one side of the tyre, the tube can be taken out for repair. Replace the valve inside and, if the puncture is small, pump up the tube and test it in water when the escape of air can be detected. Mark this place with a pencil and dry the tube thoroughly. Repairing materials are so good that it is rarely necessary to vulcanise a tube. If the directions printed on the repair outfit are followed, a satisfactory and lasting job can be made of the job. The preparation of the tube with sandpaper or the wire brush given with the outfit is most important as, if any dirt or grease is present, the patch will not stick. After the solution has been applied it should be allowed to dry for at least five minutes before the prepared patch is applied. The patch should be pressed from the middle outwards, to make sure that no air is trapped under it, and the edges firmly affixed so that it will not " lift."

Attend to the Cover.—When waiting for the solution to dry, the tyre should be carefully examined. Every inch of the inside of the cover should be inspected and any foreign bodies which have penetrated removed. The inside of the tyre should then be dusted with french chalk.

After pumping up the tube, it should again be examined in water and, if satisfactory, it is ready to be fitted to the tyre again. Make sure it is dry and dust it with french chalk when it can be placed in the cover, being careful to fit the valve centrally. The nut should be screwed on to the valve stem for one or two threads to prevent it slipping inside the rim. Now put enough air into the tube to make it take its proper shape. The next stage is to fit the tyre as far as possible by hand. Before applying a little force with the tyre lever, make sure that the edges of the tyre are in the well of the rim, when the fitting should be accomplished without difficulty.

Re-Fitting.—When the tyre is on the rim, put a little more air into the tube and push the valve inside as far as it will go. This will make certain that the stem is not gripped by the edges of the tyre. At this stage the tyre can, with advantage, be bounced on the floor all round to make sure that it is fitted evenly. After pumping it up and testing the pressure, tighten the lock-nut and the valve inside, and replace the caps. Examine the tyre all round to see that it is correctly fitted and it will be ready for the road again.

Before removing a tube which has become slowly deflated, inspect the valve for leakage. The time-honoured method of doing this is to remove the cap and place a little saliva on the stem. If air is leaking, a bubble will form and the remedy obviously is to replace the valve inside.

TYRE INTERCHANGEABILITY TABLE

In view of the fact that the majority of British motor cars are now fitted with wired-on tyres and well-base rims, the " Interchangeability List " shown will be extremely useful to the trade and public alike when making a selection of tyres.

The list has been compiled and standardised as the result of the Motor Car Standardisation Committee's deliberations, and consideration has been given to most tyres and rims in use at the present time.

Well Base Rim		Tyre Size	
Rim No.	Previous Description.		
WM.0—19	2"×19"	24"×2·375" 25"×2·75"	
WM.0—21	2" ×21"	26"×2·375" 27"×2·75"	
WM.1—19	2¼"×19"	24"×2·375" 25"×2·75"	25"×3·00"
WM.1—20	2¼"×20"	26" ×3·00"	
WM.1—21	2¼"×21"	26"×2·375" 27"×2·75"	27"×3·00"
WM.1—23	—	28"×2·75"	
WM.2—19	2½"×19"	25"×2·75" 26"×3·25"	25"×3·00" 26"×3·50"
WM.2—20	2½"×20"	26" ×3·00"	
WM.2—21	2½"×21"	27"×2·75" 28"×3·50"	27"×3·00"
WM.3—19	3" ×19"	26"×3·25" 27"×4·00" 27"×4·00"	26"×3·50"
WM.3—21	—	28"×3·50"	

Repairing Outer Covers.—The many excellent tyre, vulcanising, and service depots that are rapidly becoming more and more popular are apt to replace amateur efforts in this direction. Despite these obvious advantages, many tyres are often discarded when the owner, with a little ingenuity and the cost of a shilling or so, might obtain many more miles from the cover without any loss of reliability. The three types of tyres are shown in Fig. 395.

As an example, when a cover becomes well worn it may suffer a more or less serious cut, and the owner, instead of repairing it, discards it without more ado, and fits a new one. Provided that the cover is not perished, one or more cuts may easily be repaired without the necessity for paying out any large amount of money.

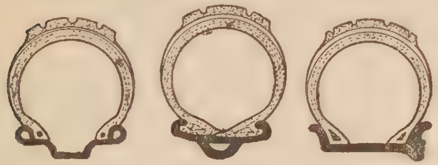


FIG. 395.—The standard types of tyre (*left to right*) wired, beaded and straight-edged.

If the cut is several inches long, it may be stopped with any of the proprietary materials now available, while as an additional safeguard an internal gaiter may also be inserted; the whole repair costing relatively little, while the tyre will be quite serviceable. In the case of small cuts, tyre stopping may again be used, while the ordinary prepared patches may be stuck inside the cover to prevent ingress of water.

Broken Casings.–The most difficult source of damage is undoubtedly a broken "casing" adjacent the bead, and if this is really serious it certainly does not pay to spend time or money in an attempt to repair it; if, however, the crack is taken in time, the aluminium repair strips that are riveted into position may be used with success.

Another point which does not appear to be generally realised is the damage that may arise through rusty rims, the rust in time flaking off and working its way into the cover.

To prevent this happening, new tyres should on no account be fitted unless the rim has first been cleaned and enamelled with a couple of coats of really good, quick-drying enamel, while in the case of old wheels a wide layer of tape placed around the rim will save endless trouble and expense. (*See* Fig. 398.)

Check Wheel Alignment.—Of course, tyres are often blamed for excessive wear, caused through no

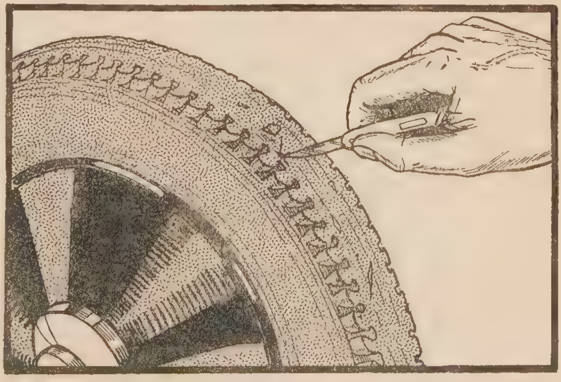


FIG. 396.—Removing Flints from the Tyre Tread.

fault of their own, but simply through mal-alignment; and a few minutes spent in "lining up" the wheels, checking with two long, straight edges may save the owner the expense of buying new tyres after small mileage has been covered.

Repairing Tubes.—As regards tubes, the modern prepared patch is hard to beat, and the practice of using sections of old inner tube for repair work is indeed a false economy, unless the repair necessitates an "outsize" in patches; then and only then can a section of tube be used with success.

Needless to say, when using other than prepared patches, the tube and the home-made patch must be thoroughly cleaned and roughened before applying the solution, and then considerable patience is required to wait until the solution has reached that "tacky" state that means a successful repair.

A mistake that is often made is to apply the patch too soon, and those little corners that start to curl up will not stick down even if further solution is applied, the only remedy being to remove the patch and start all over again.

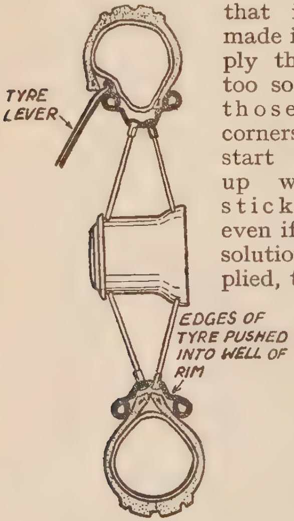


FIG. 397.—How to remove a wired-on tyre.

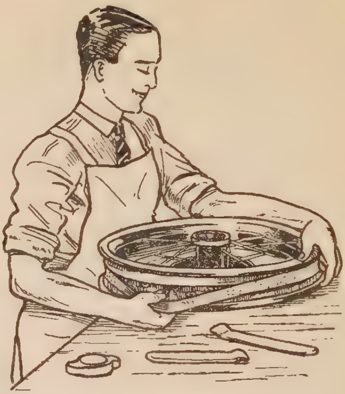


FIG. 398.—Fitting Rubber "Tape" in the Well-Base Rim to protect the Tube from chafing against the Spoke Nipples.

Removing a Patch.—At the risk of reviving an old chestnut, perhaps I may be allowed to give the old tip about removing an old patch that has suffered a puncture.

Quite a number of present-day drivers appear to be unaware as to the correct procedure, and frenzied tearing or lifting with a penknife will in all probability cause serious injury to the tube itself.

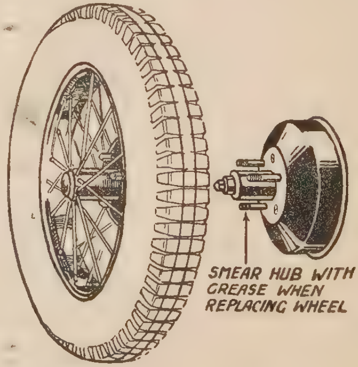

SMEAR HUB WITH GREASE WHEN REPLACING WHEEL

FIG. 399.—A bolt-on wire wheel.

Assuming that an old patch must be removed, the simplest and only way to effect its removal without damage is to cover it liberally with solution (or as an alternative a small quantity of petrol), then set it alight, and directly it starts to "sizzle" blow the flame out and the patch may be peeled off without trouble, leaving the tube undamaged.

Of course, the tube face must be well cleaned in the usual way, and obviously a large new patch must be applied to cover the old and the latest puncture.

Removing Tyres.—Tyre levers will easily effect a removal of the beaded and straight-edged tyres. The wired-on tyre is even easier to fit and remove once the knack has been mastered. After removing the valve parts, it is only necessary to push both edges of the deflated tyre into the well-base at one place when the tyre may be lifted off at the diametrically opposite point by an ordinary cycle tyre lever. To refit the tyre, push one edge of the cover over one edge of the rim into the well-base. Next, inflate the inner tube to a low pressure and place it under the cover, with the valve through the hole in the rim. Start to fit the second edge opposite the valve, pushing the edge into the well-base, and gradually easing the rest of the edge into place. Small levers may be used for the last few inches, but great stress is laid on the point that the wires are of steel, and therefore that they will not stretch, although they might quite easily become broken. If any force is required, the operation is not being correctly performed. Large levers should on no account be used (*see* Fig. 399).

Wheels.—Motor cars are of three types, the artillery, of which the Sankey wheel is a good example, the ordinary wired spoke wheel, and the disc wheel. The latter have the great advantage that they are easily cleaned, an advantage enjoyed also by the artillery wheel. It is generally admitted, however, that the spoke wheel looks neater, although it is the most troublesome of the three. Its design has not advanced to such degree that it can be run without periodical inspection and attention. Loose spokes should be tightened by means of a special nipple key, and broken spokes should be replaced. If the wheel is badly buckled, it should be sent away for re-truing, as this is not a job which the amateur can tackle. Slight bucklings, however, may be removed in the following way. Jack up the wheel and spin it, holding a piece of chalk in a fixed position so that the buckle parts are marked. The chalked parts will be the highest spots, and the spokes on that side should be slackened and those on the opposite side tightened. Effect such adjustments gradually.

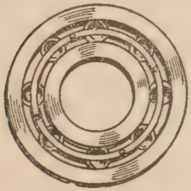


Fig. 400.—A Ball-race, as fitted to the wheels of some light cars.

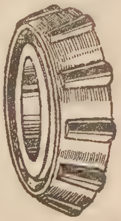


Fig. 401.—Taper Rollers for load and end thrust.

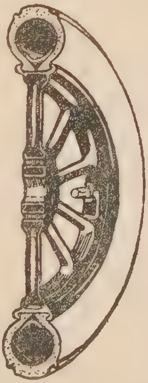


Fig. 402.—A Section of a Sankey wheel.

Tyres, Re-cutting. — Motorists who continue using tyres which have worn smooth, or are in other respects a danger to road traffic through their possibility of skidding, incur the risk of legal proceedings under recent Road Traffic Acts for neglecting to maintain their vehicles in a roadworthy condition.

This is a mere statement of fact, the object of the new legislation being to reduce the number of road accidents from removable and well ascertained causes.

As a measure of improving and maintaining tyres is a usable state, the comparatively recent practice of having the treads re-grooved is assuming considerable importance. In America, for example, there are already specially equipped tyre re-grooving stations.

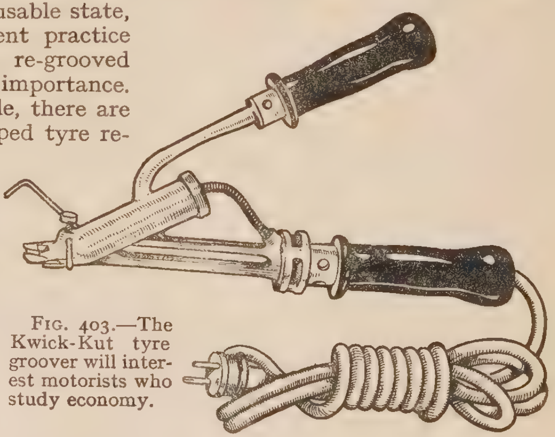


FIG. 403.—The Kwick-Kut tyre groover will interest motorists who study economy.

Longer Tyre Life.—Apart from the aspects of roadworthiness and safety, there is the advantage of the longer life assured for the re-grooved tyre. It has been estimated that a further mileage of 2,000 can be attained by a re-grooved air tyre if the treatment is given before the tread has worn smooth, and provided, too, that the canvas fabric is in good condition.

The cost of having a set of tyres re-grooved is quite moderate, but naturally varies according to the machine used and the particular requirements of each job. As a guide, however, the prices charged for work with one of the circumferential re-grooving machines are as follows : 1*s.* 6*d.* per tyre for two grooves, 2*s.* for three and 2*s.* 6*d.* for four grooves, up to a 6 in. tyre.

A Variety of Machines.—There are already a variety of machines and tools for the job. One of these (the " Pneugrippa,") is motor-driven, and grooves the tread transversely. The tyre is held vertically between concave spools and is rotated by a motor which also operates a shallow-toothed, rotary cutter mounted on a splined shaft and is kept traversing to and fro across the tyre. The operation is entirely automatic, including the spacing of the grooves—usually about 300 to 350 for a standard size cover—and inclusive, too, of the gross number of cuts on many tyres, duly registered on a recording-counter.

Another type of machine consists of a box-like metal frame with flanged side members for resting on the floor. Its mechanism consists of a pair of adjustable screw-shafts operated by hand. The shafts control the movement of a single-point cutter for either a transverse movement across the face of the tyre or for a circumferential grooving movement. The necessary power is supplied by raising the wheels of the car and revolving them in turn.

Two Further Types.—Another

example of the circumferential grooving machine has a pair of fluted rollers between which the tyred-wheel rests, and is revolved by a handle and bevel gearing. The grooving tool is first adjusted for the required depth of groove, and the tyred wheel revolved forwards so that it presses against the cutter. The job takes about five minutes for an average cover, the number of grooves ranging from two to five according to the cross-section width of the tyre.

A further form of tool resembles a painter's flat stripping knife, with a "V" pointed cutter. This is operated by hand and the cutter is electrically heated by plugging into a main supply. A special feature of the hand tool is that though the job is necessarily slower than by the straight cut grooving machines, the hand groover can be used to recut zig-zag and criss-cross patterns as well as for straight circumferential and transverse grooving.

ENGINE - OPERATED TYRE PUMPS.—In the old days when tyres were not so reliable and repairs on the road were a common occurrence, there were many tyre pumps on the market which were operated by the engine. As tyres became more reliable the demand for these pumps faded away and with free air available at most garages, they have not been heard of for many years. Lately, however, there has been a certain amount of demand for this type of accessory and an increasing number of motorists appear to be using it. It is difficult to say why this demand has been

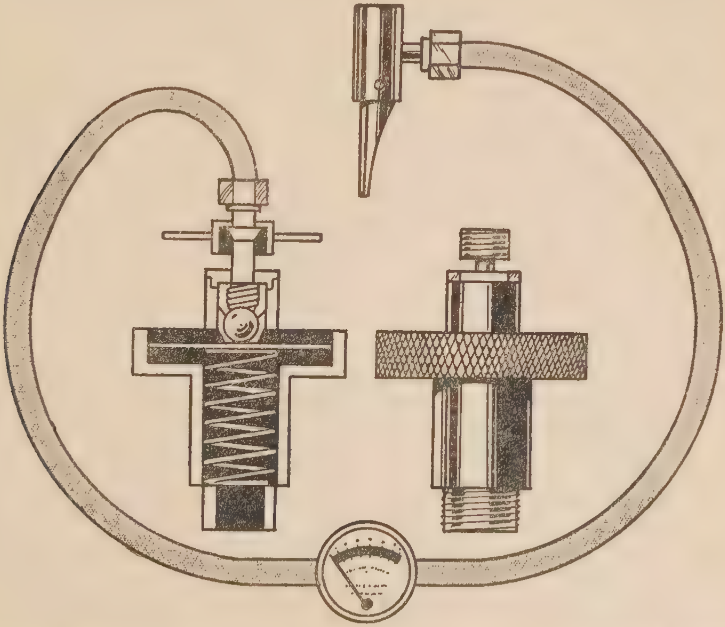


FIG. 404.—Sectional view of one type of Engine-operated Tyre-Pumping System.

created. There is no doubt that many motorists do not like to avail themselves of the free air offered at garages unless they are in the habit of purchasing all their supplies at the same place. Garage proprietors are not too willing to give the services of a mechanic free to a chance customer who wants two gallons of petrol, on which he makes fourpence gross profit, and his five tyres tested and pumped up. After all it is asking rather a lot when one is not a regular customer.

There are two types of pump for inflating the tyres by engine power. One is run mechanically off the timing gear and this type must be fitted to the engine when it is made. Some lorries have them fitted as standard. The other type is screwed into the sparking-plug hole and, when the engine is run, will pump clean air into the tube. The fact that clean air is pumped is stressed because there have been types on the market which filled the tyre with petrol fumes to the detriment of the rubber. High-pressure tyres were not very suitable for this type of pump as the pressure generated is not, of course, higher than the compression ratio of the engine. With the modern balloon tyre the pressure is more than sufficient for the largest vehicle.

Though the pump screws into the sparking-plug hole after this component has been removed, there is no direct connection between the gases in the cylinder and the pump hose. The body of the pump contains a steel diaphragm which is so placed that when the engine piston is on the suction stroke, it is drawn down thus exposing a number of holes in the pump body. Air is thus admitted, and when the piston of the engine is on the compression stroke, the diaphragm is forced up, first covering the air-inlet holes and then compressing the air, which is delivered into the usual pump hose through a non-return valve. A pressure gauge is inserted in the pump hose to indicate the pressure in the tyre, and the hose supplied is long enough to reach all round the car The pump is very reliable in use, and there is nothing in its construction to go wrong. It is very convenient for the motorist who does not want to exert himself by using the normal type of hand- or foot-pump. After all it does take a fair amount of energy to pump up a tyre to the proper pressure, even when low-pressure tyres are fitted, and if some 7 or 8 lbs. have to be put in each, which amount is not unusual when very frequent attention is not possible, only the more robust drivers will really revel in the job.

TYRE GAUGE.—A small pressure gauge which is screwed on to the air valve of the inner tube and which indicates the pressure of air.

U

UNION.—A term which describes a simple form of connection for a pipe, the end of the pipe being generally placed in a socket or depression provided in the other member and a hollow nut being screwed up over the joint.

UNIVERSAL JOINT.—A joint between two rotating shafts which permits of the side-to-side movement of one of them without severing the power connection between them.

A universal joint is fitted to the propeller shaft of a car between the gearbox and the back axle in order to allow for the relative movements of the latter.

UPPER CYLINDER.—The interior portion of the cylinder above the piston-head.

V

VACUUM BRAKES.—The vacuum-braking system has been applied to many well-known cars, but it is not a method of applying the brakes which is altogether independent of the driver's effort. The vacuum system assists the driver in applying his brakes, and can be likened to a mighty hand which clutches the brake and applies it as soon as the driver's foot has moved the pedal a fraction of an inch. It is a very safe method, in that the driver has direct control over the brakes at all times, and can actually feel the pressure he is applying to the shoes. The brake-pedal is directly connected to the operating mechanism just as it is in direct braking systems, and should anything go wrong with the vacuum system, he still has his brakes available though a little extra pressure must be applied. With the vacuum system the effort necessary to apply the brake is very small. With the system in reasonable condition the pressure applied by the foot is increased four times by the vacuum motor, which means that only about a quarter the normal pressure is required to pull up the car.

As its name implies, the system works by vacuum, and this is obtained by the pumping action of the engine. When an engine is running, it pumps mixture out of the induction pipe with every inlet stroke of each piston. Thus when the throttle is closed the engine is acting as a very efficient pump, and as very little air and mixture can enter the induction pipe round the edges of the throttle, a high vacuum is created. It is this vacuum which operates the windscreen-wiper, and because the vacuum is highest when the throttle is closed, the arm works fastest at slow engine speeds.

When the brakes are applied the throttle is released and almost instantly the vacuum in the induction pipe becomes very high. Thus we have a high vacuum available to assist our brakes at the very time we require it, and by means of the servo motor this vacuum is made use of.

By referring to the sketch you will see that the brake-pedal is connected directly to the brake-operating rods. Thus the direct pressure is applied. A link is connected from this fulcrum point where the pedal-lever and the brake-rod are joined, and the end of this link has a chain connection to a piston which operates in a cylinder. Now this cylinder is connected with the induction pipe by means of a tube with a valve incorporated in it. As soon as the brake-pedal is slightly depressed the valve is automatically opened, thus allowing the air in the cylinder to be drawn into the induction pipe, where it is removed by the pumping action of the engine. All this happens in a split second. The atmospheric pressure on the outside of the piston then moves it forward with a very powerful action and, as it is connected through the chain to the brake-operating rod, this rod is pulled with it. The vacuum action is thus made to help the driver's effort. As soon as the brake-pedal is released, another valve is opened which allows air to escape into the cylinder. The spring, which is on top of the piston, then forces it back to its normal position, releasing the brake mechanism at the same time. This action is practically instantaneous. The piston works in oil so that its movement is not violent, and the oil also forms a seal between the piston and the walls of the cylinder.

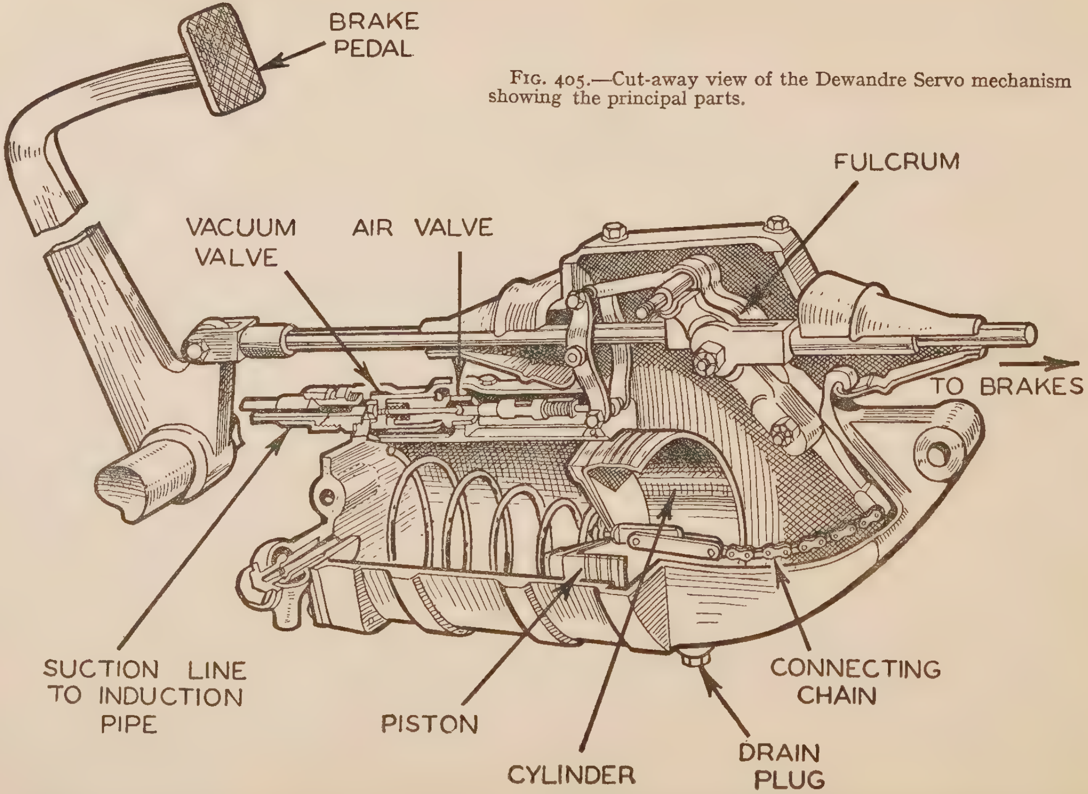
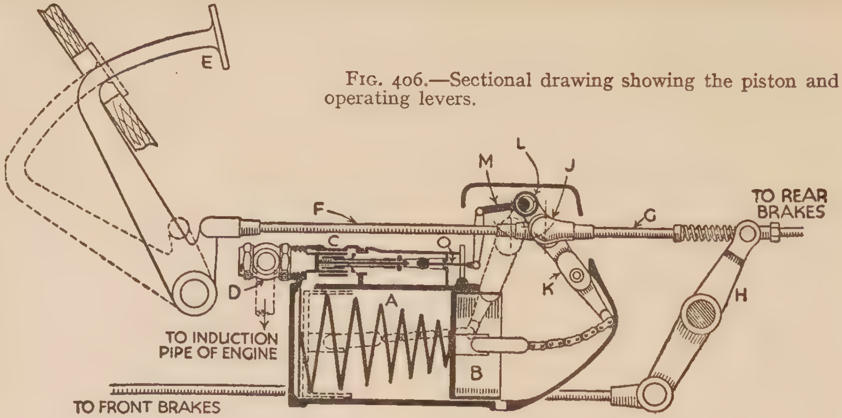
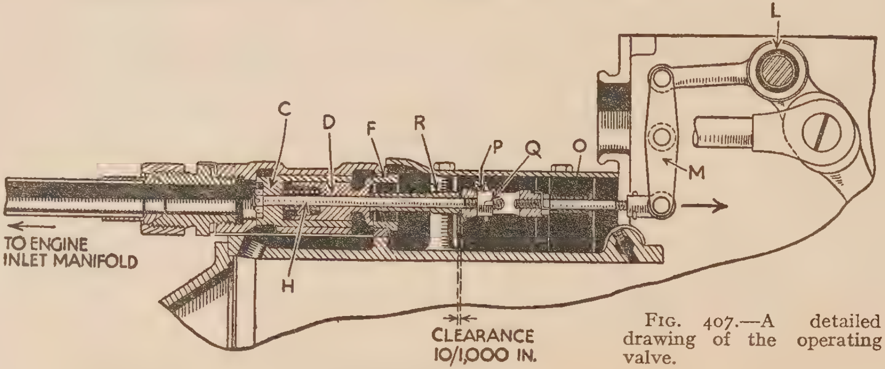

BRAKE PEDAL
FULCRUM
VACUUM VALVE
AIR VALVE
TO BRAKES
SUCTION LINE TO INDUCTION PIPE
PISTON
CYLINDER
CONNECTING CHAIN
DRAIN PLUG

FIG. 405.—Cut-away view of the Dewandre Servo mechanism showing the principal parts.



E
M
L
J
F
C
G
TO REAR BRAKES
D
K
H
A
TO INDUCTION PIPE OF ENGINE
B
TO FRONT BRAKES

FIG. 406.—Sectional drawing showing the piston and operating levers.



L
C
D
F
R
P
Q
O
M
TO ENGINE INLET MANIFOLD
H
CLEARANCE 10/1,000 IN.

FIG. 407.—A detailed drawing of the operating valve.

FIGS. 406 and 407.—A, cylinder; B, piston; C, valve; D, connecting pipe; E, operating pedal; F and G, brake pedal rods; H, articulating lever; J, pivot; K, compound lever; L, pivot; M, push rod; N, rocking lever; O, valve rod; P and Q, adjustments; R, sleeve.

The brake-pedal is depressed when the engine is idling, it will speed up for a moment due to the air which has been admitted, but will return to the normal tick over immediately. If it continues to run faster than when the pedal is not being touched, there is some leak in the pipe which leads to the inlet manifold, or some other part of the mechanism. Practically the only possible fault which can occur in the system is leakage and this can be overcome by a little attention. A failure to operate efficiently may also be due to wear in the cylinder or piston which will allow a leakage of air into the inlet pipe. Provided that all joints are tight this will be the reason of bad idling and starting, and can only be put right by the replacement of the worn parts. The valves rarely need attention, and their adjustment is beyond the usual owner-driver. Special tools are also required to make the adjustments so that, if these parts are suspected, it is better to take the car to the service station. It is not every garage who understand the servicing of vacuum-braking systems, so that the job is best done by the agents for the car in question.

As the piston runs in oil it is necessary to change this periodically. There is a drain plug provided for the purpose, and a vent hole to ascertain the level of the oil. The casing should be examined occasionally to see that there is no oil leak from the plug.

The gaiters which cover the rods, where they fit into the casing of the motor, should be kept in good condition, as dirt will soon interfere with the action of the mechanism. " Popping back " from the engine will deposit soot on the valves and this should be avoided as far as possible. After starting up, the engine should not be pushed when cold thus causing back-firing in the carburettor. The soot formed is liable to be blown on to the valve seatings, thus preventing them closing properly.

As the vacuum system is only used to assist and augment the foot pressure, the adjustment of the brakes is no different to the normal system. Though the action is more powerful this will not make up for worn linings and other faults in the brake-shoes themselves. Because the action of the brake is more powerful and the driver relies on this power when driving, any inequality in adjustment is rather accentuated. It is important, therefore, that the brakes should be efficiently equalised and accurately adjusted, when it will be found that they will not need any attention for long periods if the linings are in good condition.

Though the operating mechanism is out of sight, the casing should be cleaned at intervals or dirt and grit will work their way in. The rods, particularly, should not be allowed to accumulate the black, greasy deposit which is sometimes found on the underparts of a car.

With the vacuum servo system extra air valves, which admit an unusually large quantity of air to the induction pipe, should be avoided as they tend to reduce the vacuum. An idling mixture which is set very weak may also cause trouble, as the extra air admitted for a moment when the brake is operated may stall the engine unless the idling is positive.

VALVE.—In automobile engineering this term usually refers to the mechanically-operated valves which are attached to the engine cylinders for the purpose of allowing the fuel gases to enter and depart from the cylinders.

VALVE ADJUSTMENT.—The valves of an engine must lift and fall on their seats some 800 times a minute at normal car speeds, and they must lift high enough to give the fullest area of inlet and escape for the gases. The exhaust valves are subjected to burning gases every time they open and for the whole period during which they are open. Both valves must seat so as to make a gas-tight joint during compression or the efficiency of the engine will be seriously reduced.

Bad Seating.—Carbon deposit, scaling of the valve face and pitting of the valve seat must occur to a more or less serious extent in the course of extended running; and periodically the valves must be re-seated. The valve face, and the seat upon which it rests to close the aperture, must be carefully ground to so fit each other that, when engaged (when the valve is "seated") no gas—mixture or exhaust—can pass. If the exhaust valve does not seat properly and closely hot gases are drawn in through it on the induction stroke from the exhaust manifold and reduce the efficiency (from the point of view of expansion) of the gas charge drawn in which will be reduced and will be diluted with the burnt product of combustion. If the inlet valve does not seat, burning gas will be sent back, on the power stroke, into the manifold and cause "popping" in the carburettor or the inlet pipe.

Valve Lift.—The lift of the valves is as important as the efficiency of their seating. Continual hammer of the tappets in the case of the side valve engine, with the addition of the overhead rocker and the push rods in the case of the overhead valve engine, reduce the lift of the valve off its seat. (We call it "lift" even in the case of the inverted overhead valve which moves downwards from its seat in opening.) If the lift is not sufficient the incoming gas will be throttled, the engine partially starved and the exhaust gas will be retarded in its expulsion from the cylinder. These two faults will act cumulatively in reducing the power which will fall off seriously and speed will be reduced. Valves must therefore be periodically ground upon their seats and the clearances of tappets and rocker levers adjusted—in the first place to ensure a gas-tight joint when closed and in the second to ensure a full opening of the valve.

Late Opening—Early Closing.—If the gap between the tappets and the valves, or between the tappets and the push-rods or between the rocker levers and the valve stems is too great the valve will not only fail to open fully, but it will open late and close early, thus multiplying the error and reducing the power given out by restricting the amount of explosive gas drawn into the cylinder. But it is of little avail making adjustment of the clearance if the valves require grinding-in because the latter operation will alter the clearances. It is wise, therefore, to attend to the grinding first and set the clearances afterwards.

Grinding-in the Valves.—To grind the valves on their seats the following procedure should be followed: The cylinder-head should be removed. Then the valve springs should be compressed with a valve-spring compressor which holds the head of the valve down while pressing up the washer below the spring. This done the cotter, which confines the washer and the spring, can be pulled out and the spring released. It will spring down below the end of the valve stem and the valve may be pulled out of its guide and clear of its seat and taken away. The stem should be cleaned with paraffin and a paraffin rag drawn through the valve-stem guide to clear it of gummy oil. Then the valve should be replaced in its guide but with a coil spring under its head. This spring can be made of a piece of thin bicycle spoke-wire wound round a piece of rod (wood or iron) of about ½ in. diameter. The arrangement is shown on Fig. 408. The cam, A, has left the flat face of the tappet, B, which is at the bottom of its travel, so the valve, C, the spring of which has been removed as well as the cotter and washer which retain it, can be seated and pressed down on its seat by a screwdriver, D, used for partially rotating it while grinding it. The temporary coil spring, E, lifts it off its seat when the pressure on the screwdriver is released. The valve stem and the guide F should be lubricated with thick oil.

Grinding-in.—The grinding-in process consists of smearing the face of the valve with corn emery, or carborundum powder mixed with vaseline paste. This compound can be obtained ready mixed—coarse for roughing-in and fine for finishing. The valve is then inserted into the guide and on to its seat and is given about a dozen turns backwards and forwards with a good pressure on the top of the screwdriver. This pressure should then be released, when the spring E will lift the valve off its seat. The valve is then given a half turn, so as to bring it down in a different place on the seating and the grinding is continued. When the valve is lifted off its seat the finger may be drawn round the seat to redistribute the grinding medium, and occasionally fresh grinding medium should be smeared on the face of the valve. This grinding is continued till the face of the valve and its seat are both a dull grey colour with no black spots and no lines—a band of grey of equal thickness

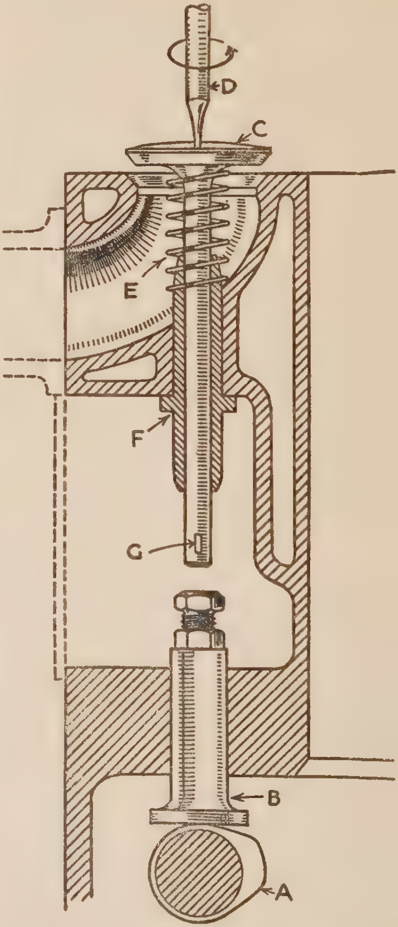


Fig. 408.—Valve in position with light spring interposed, ready for grinding-in.

all round. When this result has been obtained the grinding may be finished with the finer grade of carborundum grinding paste. All paste and oil should be cleaned away with paraffin oil and the parts wiped dry with dry rag.

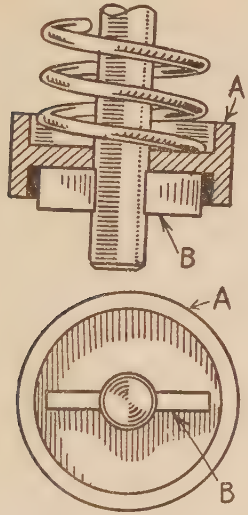


Fig. 409.—One design of valve cotter. A is a recessed washer which locates the spring. B is a cotter which fits in a slot in the valve stem.

Re-adjusting.—The valves may then be replaced (each valve of a set will, of course, have been ground into its own original seat). The spring will first be pushed up around the valve guide, and then the washer below it will be slipped over the end. Then the spring is compressed by the valve-spring tool and the valve is pushed down its stem and guided through the retaining washer till the cotter hole, G, is clear of the washer. The cotter is then inserted and the spring released. Two different forms of cottering are shown at Figs. 409 and 410. Fig. 409 shows the conventional type. The washer, A, has a rim each side. The top rim locates the spring and the bottom ring holds the cotter, B, endways. In Fig. 410 a tapered (conical) sleeve, C, in two halves, fits in a groove around the valve stem; it is placed in position while the spring is held up by its retaining washer. This washer, E, has a rim on the top which locates the valve spring and it is tapered inside to fit the halved taper sleeve so that when pressed down by the spring it holds the sleeve tight in the groove in the valve stem; the sleeve holds the washer, E, against the pressure of the spring.

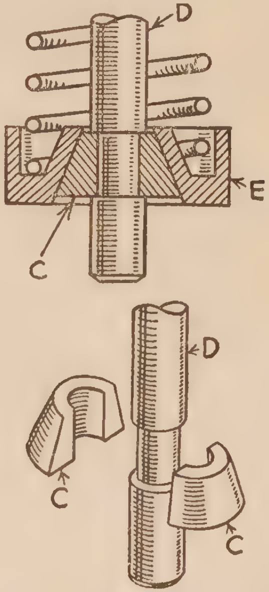


Fig. 410.—Another method of fixing the spring to the valve stem. As will be seen it is achieved by a split tapered collar and retaining cap.

Adjusting Valve Clearances.—Adjustment of the valve clearance on a typical engine is made as shown in Fig. 411. The tappet, A, has a hardened screw, B, screwed in its top with a hardened lock-nut, C. The head of B abuts against the bottom of the valve stem, D, and lifts the valve when the cam raises the tappet (*see* Fig. 408). There should be a clearance between the bottom of the valve stem and the top of the tappet adjustment screw to ensure that the valve sits down on its seat. This adjustment is made the last operation in the job of valve grinding. It is carried out after the cylinder-head has been replaced and the engine has been run till it is warmed up to reach normal running temperature. Obviously it is useless to make the final clearance adjustments to a cold engine, since they will be altered by temperature variations when the engine is hot. Different manufacturers specify their own settings for these clearances, but on a typical touring side-valve engine they should be ·004 ins. for inlets and ·005 for exhaust valves. To make the adjustment, slack off the lock nut, C, so as to free the adjustment screw, B. Have the tappet at the bottom with the cam away from it (as shown in Fig. 408), then screw up the hardened screw, B, till it has the correct clearance. Measure this with a feeler-gauge of the right size, and lock with the lock-nut, C. The adjustment must be checked afterwards, as the tightening process tends to vary the setting slightly. All the inlet valves should have exactly the same clearances and similarly all the exhaust valves.

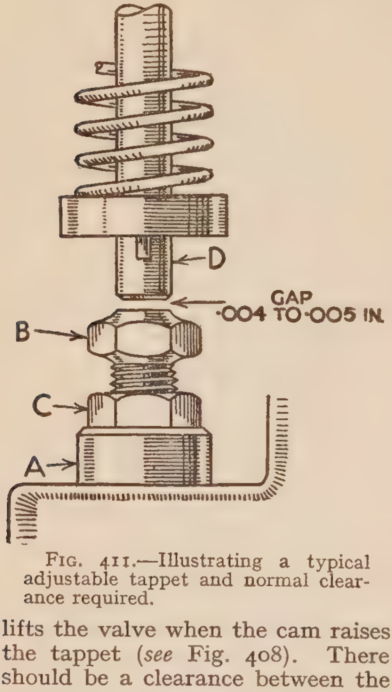


FIG. 411.—Illustrating a typical adjustable tappet and normal clearance required.

VALVE CAP.—A metal cover or cap which is screwed into the pocket providing access to the valve.

VALVE CHAMBER.—In some old car engines this is a continuation of the combustion chamber, projecting from the side of the latter and allowing the valves to open into it.

VALVE COVER.—A metal plate which covers over the working parts of the valves, protecting them from dust and serving to reduce the noise of their operation.

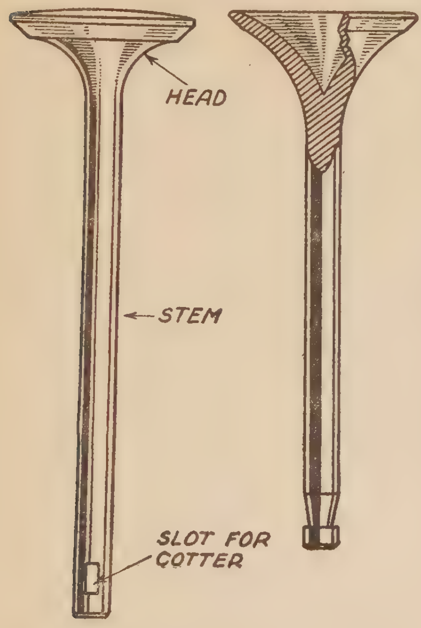
VALVE GUIDE.—A metal collar through which the stem of the valve passes thus securing accurate positioning of the latter.

VALVE HEAD.—The round, flat disc formed at the top of the valve stem, which bears in a ring or hole in the cylinder through which gas is admitted or released from the latter.

VALVE PLATE.—See *Bolt valve-plate*.

VALVE PORT.—A short tube leading from the valve to the cylinder and to which the valve is fitted.

VALVES AND VALVE ACTUATING MECHANISM.—The great increase in the power output of modern engines can be attributed in a large measure to the improved methods of getting the explosive petrol vapour into the cylinders and removing the burnt gases after ignition. This operation is carried out by means of *valves* which cover and uncover holes or *ports* in the head of the cylinder. The correct instant for the opening and closing of the ports is controlled by various cam devices which are driven by gearing from the crankshaft.



FIGS. 412 and 413.—Examples of Valves. That on the *right* is a " tulip " valve.

The type of valve which is almost universally used in light car engines is known as the poppet or mushroom valve and is the type with which we shall deal here. There are other types such as single and double sleeve valves, rotary and piston valves, but only the sleeve valve has offered any serious competition and this is usually employed on the larger and more expensive cars. The Daimler-Knight is probably the best known and most successful example of the sleeve valve engine.

Modern poppet valves are almost invariably made from a single steel forging, although those made in two parts, namely with a cast-iron head and steel stems have been used to some extent in the past.

Examples of the two main types of valve are illustrated in Figs. 412 and 413. That in Fig. 412 is the more usual kind while the other one, which is called a " tulip " valve, is a lighter pattern having a hollow trumpet-shaped head and often a hollow stem. This latter one is used on many fast "revving" sports and racing cars, in which the reduction of the weight of all the reciprocating parts of the engine is of paramount importance.

Fig. 414 shows the general arrangement of a poppet valve in the cylinder casting. It slides up and down in a cast-iron sleeve or guide, so that when it is raised it uncovers the passage or port leading into the cylinder and when it is lowered it closes the port. There are usually two such ports to each cylinder, one being used to admit the explosive mixture into the cylinder from the carburettor, and the other being employed to allow the escape of the gaseous products of the combustion after the petrol vapour has been fired by the electric spark at the sparking plug and has done its work in pushing down the piston. The example shows the inlet port; the exhaust port being directly behind this and therefore not shown.

At the moment the valve is raised, while the piston is descending on the intake stroke. The passage of the incoming petrol vapour which is sucked in by the descending piston is shown by the dotted lines.

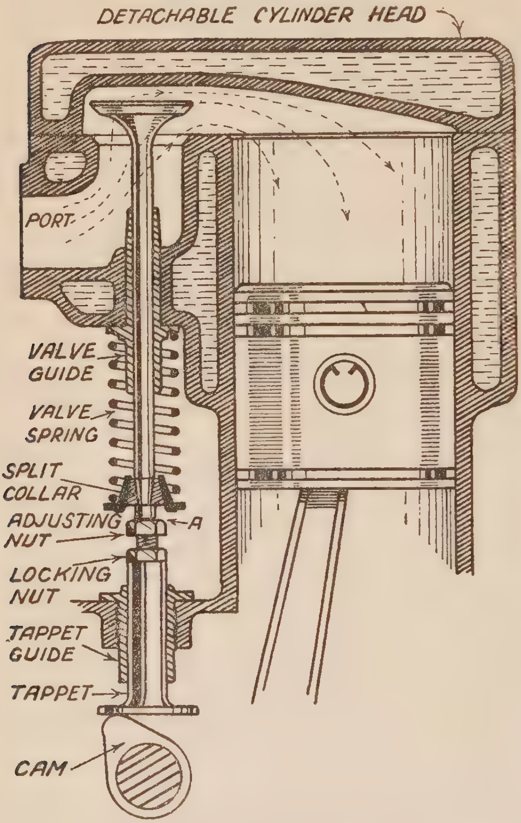


Fig. 414.—Section of a Side-valve Engine showing details of valve and operating mechanism.

The shape of a modern valve and the material of which it is constructed is the outcome of many years of intensive research. In order to understand the difficulties which have to be overcome and the reason for the design now employed, it is necessary to appreciate the conditions under which a valve works. First of all it is obvious that each valve must open and close once for every complete cycle of operations, that is, for two revolutions of the crankshaft. Thus, if the engine is turning over at 3,000 revolutions per minute it means that the inlet port must be opened 1,500 times and the exhaust port the same number of times per minute. The rapid raising and lowering of each valve thus entailed necessitates that it shall be of light weight, otherwise the inertia to be overcome is so great as to cause immense strain on the operating mechanism. At the same time the valve must be sufficiently strong to resist the hammering effect which occurs every time it closes. It stands to reason that at a high speed of operation that the head of the valve must come down with considerable force on its seating when it is lowered to close the port. This naturally tends to wrench the head from the stem. The stem also has to withstand the wear caused by its movement up and down in the guide; in fact, in some engines no proper means of lubrication is provided between the stem and guide. One of the greatest difficulties to be overcome we have not yet mentioned, namely the softening and deterioration of the metal caused by the intense heat in which the valve operates. In the early days of motoring this was almost insurmountable, the replacement of an exhaust valve being quite a usual occurrence on a short run. Of course, the exhaust valve is the one subject to the severest conditions, since the head and upper part of the stem are entirely surrounded by the intensely hot flame of the burning gases every time it is opened, while it is not cooled by the incoming petrol vapour as is the inlet valve. Besides the softening effect due to the heat there is also the corrosive action of the exhaust gases themselves which tend to burn the metal. If the head becomes pitted round the outside edge where it comes in contact with the seating it will not provide an air-tight joint when closed, thus allowing air to enter or gas to escape from the cylinder at the wrong time and so lowering the efficiency of the engine.

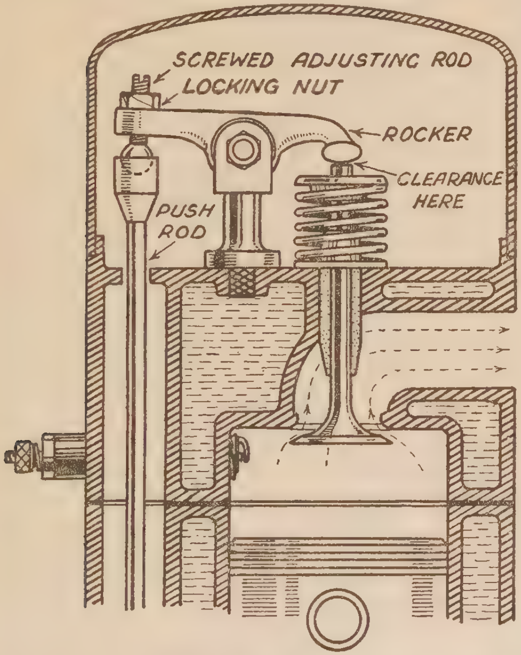


Fig. 415.—Overhead Valve actuated by means of push-rod and rocker.

Construction of Poppet Valve.—It has been found that the use of special alloy steels combined with the construction shown in Figs. 412 and 413 has enabled the production of valves which will stand up to the exacting conditions encountered in modern engines with every success, so that valve breakages are now very rare indeed, even in racing engines capable of "revving" at 8,000 revolutions or more per minute. The most usual alloys are chromium, nickel, cobalt, and silicon. With these alloys pitting of the valve head and fractures at the junction of the head and stem are eliminated. The prevention of fracture is further assisted by the gradual thickening of the stem where it merges into the head. Other points in the construction which should be noted include the chamfered or bevelled edge of the valve head. The angle of the bevel is usually 45 degrees, and, of course, the circular seating on which it rests when closed is ground to the same angle. With this construction the head locates itself automatically in its seating when the valve closes, even when the stem has become worn and allows the valve to move sideways in the guide. The pressure of the gas in the cylinder also assists in keeping the valve on its seating.

In Fig. 414 the valve is shown passing through a detachable guide. This is the usual arrangement and has the advantage that the guide can be made of different material from the cylinder block and with better wear-resisting properties. It can also be replaced when wear does finally manifest itself. However, this is by no means universal practice, and many engines dispense with a guide and pass the valve stem through a suitable boss in the cylinder casting.

Position of Valves in Cylinder Head.—The location of the valves in the cylinder head has an important bearing on the efficiency of the engine. It is obviously closely allied with the design of the head itself, and in fact, it is difficult to treat it as a separate subject. Besides the question of getting the gases in and out of the cylinder as quickly as possible there is also the promotion of turbulence, the position of the sparking plug, adequate cooling of the ports and the prevention of distortion of the cylinder head, etc., to be considered. The two usual arrangements are the side-by-side position as shown in Fig. 414, and the overhead position illustrated in Figs. 416, 417, and 418, etc. The former is rather the more popular, as it is usually cheaper and calls for less elaborate actuating mechanism. The overhead system, however, enables the design of a better shaped combustion chamber and makes for greater efficiency. There are several ways in which overhead valves can be placed and operated. They may be vertical as in Fig. 415, when they can be operated by a single overhead camshaft or by a camshaft situated in the crankcase and actuating the valves through the medium of pushrods and rockers. Alternatively, they may be set diagonally as in Fig. 416. This latter system enables the design of a combustion head approaching more nearly to the ideal spherical shape.

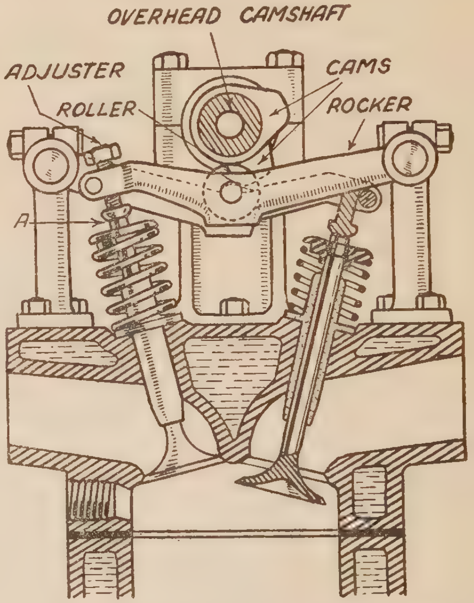


Fig. 416.—Well-thought-out Overhead Camshaft design operating inclined valves.

Operating Gear.—The design of the gearing necessary to actuate poppet valves in automobile engines has been given considerable atten-

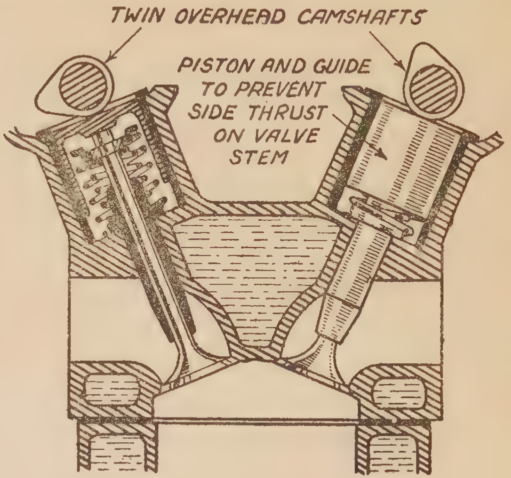

TWIN OVERHEAD CAMSHAFTS
PISTON AND GUIDE TO PREVENT SIDE THRUST ON VALVE STEM

FIG. 417.—(*Above*) Advanced Overhead Valve design with twin Camshafts and minimum of reciprocating parts.

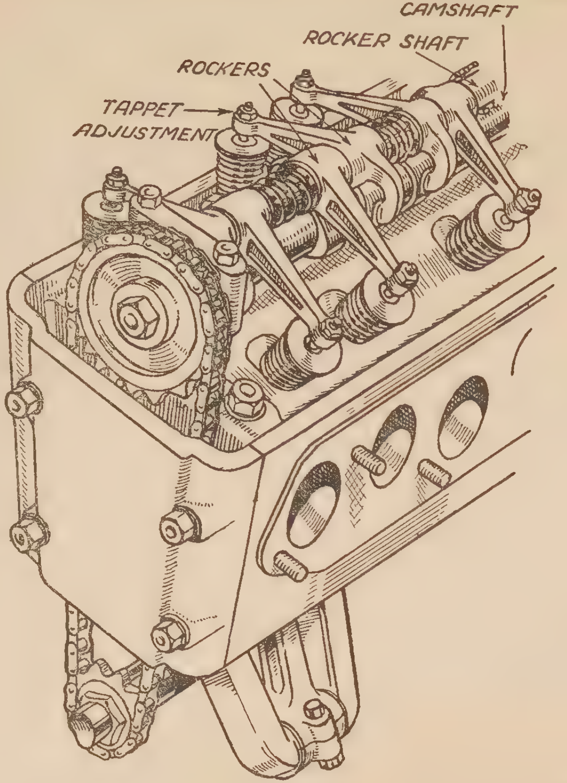

CAMSHAFT
ROCKER SHAFT
ROCKERS
TAPPET ADJUSTMENT

FIG. 418.—(*Left*) Popular Overhead Valve arrangement employing Chain-driven Camshaft.

tion recently, partly due to the stimulus provided by the success of the sleeve valve engine. We will deal first with the mechanism used to transmit the drive from the crankshaft to the half-time shaft, and then with the devices employed to link the half-time shaft with the valves themselves.

Whatever the type of valve used it is always necessary to drive it from a camshaft which revolves at half the speed of the engine, since each valve is required to operate only once per revolution of the crankshaft. The necessary gearing for driving the camshaft is invariably situated at the front of the engine, that is, the end remote from the flywheel. In Fig. 419 are shown some of the most popular arrangements. The simplest arrangement consists merely of a pinion wheel mounted on the end of the crankshaft which meshes with another spur wheel having twice the number of teeth, and carried on the end of the camshaft; the camshaft therefore revolves once for every complete turn of the crankshaft. However, the distance between the engine shaft and the camshaft usually necessitates the use of an intermediate wheel as depicted in the bottom left-hand illustration in Fig. 419. This is the

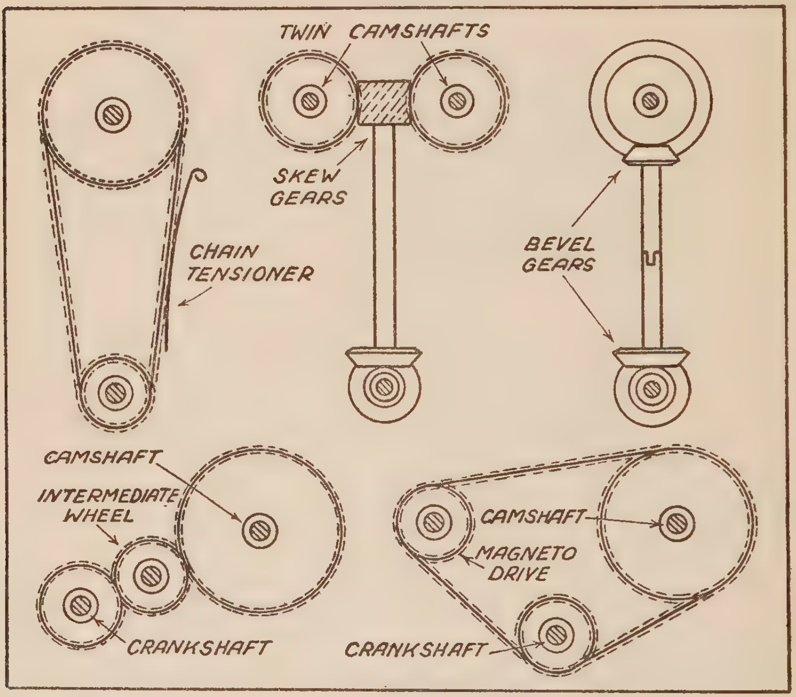


Fig. 419.—Various methods of driving the Camshaft used to operate poppet valves.

system employed on many side-valve engines where the camshaft is, of course, situated in the crankcase. Another very usual drive for side-valve engines is by chain. The chain used is usually of the " silent " type and operates on accurately cut gear wheels or sprockets. Often a triangular drive such as that shown in Fig. 419 is employed. The chain passes over the crankshaft and camshaft sprockets and also over a third sprocket which drives the magneto and possibly the water pump as well.

A very good idea of the layout of the valve gear of a typical side-valve engine is given by the cutaway drawing in Fig. 414. Here the silent chain drive to the camshaft is clearly shown. Overhead camshafts, that is, those carried above the cylinder block instead of below it, can be operated either by gears or chain. A train of spur wheels is not used to any great extent, but vertical shafts driven by bevels or by spur wheels are quite common, although the perfection of high-speed silent and roller type chains, which has been attained within the last few years, has led to an increased use of this cheap and silent form of drive. One of the advantages of the chain drive is the ease of adjustment,a simple automatic spring tensioner such as that shown in Fig. 419 being quite satisfactory. The gears used in shaft drive on the other hand have to be very accurately meshed, otherwise excessive noise will result. This necessitates some means for allowing for the expansion of the cylinder block when hot, otherwise the gears will alter their degree of meshing or engagement with the expansion and contraction of the block. The illustration in the top right-hand corner of Fig. 419 shows one method in which a divided vertical shaft is employed. The necessary expansion and contraction takes place at the sliding joint between the two halves. When the valves are set at an angle in the cylinder it is quite common to use two overhead camshafts and one modern arrangement for driving these shafts is shown in Fig. 419 and is that employed on the latest British Salmson car. The vertical shaft, which rotates at engine speed, is driven by bevel gears from the crankshaft, while the drive to the camshafts and the half-speed reduction is carried out by skew gears.

Cams and Rockers.—There are many different ways of operating the valves from the camshaft. With side-valve engines the arrangement depicted in Figs. 417 and 418, with very slight modifications, is almost universally employed. Referring to Fig. 414 it will be clear how the valve slides up and down in the sleeve or guide as already mentioned. The valve is held in the closed position by means of a coil spring which is under compression. The upper end of the spring abuts against the under-side of the collar which forms part of the guide, while the lower end bears on a washer resting on a split collar or on a cotter pin which passes through the lower end of the valve stem. The valve is opened by means of a plunger called a *tappet* which pushes against the end of the valve stem. The tappet slides in a guide similar to the valve guide. It is the eccentric or cam carried by the rotating camshaft which causes the tappet to move up and down and thus operate the valve. In the examples shown in Figs. 417 and 418 the lower end of the tappet terminates in a flat or mushroom foot, but there are also other types with a roller foot to reduce friction and also some with plain ends.

The shape of the cam is usually such as to produce a lift of the valve equal to about one-fifth the diameter of the seating. However, there is no hard-and-fast rule as to the shape of the cam as it depends on the size of the valve, the speed of rotation, the permissible stresses on the mechanism, etc. A pear-shaped cam gives a more gradual opening and closing, and therefore less stress, quieter operation, and longer life, but a cam with a squarish outline jerks the valve open quicker, thus allowing the gases to enter and leave the cylinder more expeditiously. This produces a more efficient and powerful engine, but is noisy and sets up greater stresses. Incidentally, strong-valve springs are also required to close the valves rapidly and these naturally increase the wear-and-tear.

Fig. 419 shows a very common arrangement for operating overhead valves from a camshaft contained in the crank case. The camshaft and tappets are usually similar to those detached in Fig. 405, while a hollow push rod is used as the link between the tappet and the overhead rocker which operates the valve. This latter is a lever bearing directly on the end of the valve stem as shown. Sometimes the rocker is mounted on roller bearings, but in the cheaper cars plain bearings are employed. The disadvantages of the push rod method are the large number of reciprocating parts and a tendency in some instances to noisy operation.

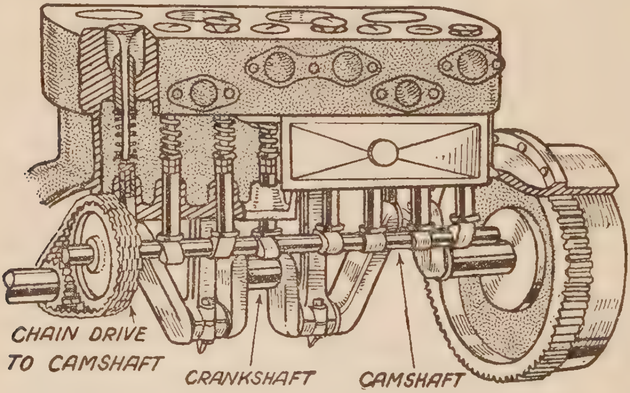


Fig. 420.—Cut-away View of typical Side-valve Engine, showing valve gear.

There distinct methods of actuating valves from overhead camshafts are shown in Figs. 417 and 418. In Fig. 417 is shown a well-thought-out design in which a central camshaft operates the valves by means of long rockers. The cam slides over rollers carried in the middle of the rocker arm while the long distance from the fulcram of the lever to the tappet end produces only a small lateral or sliding movement of the tappet on the end of the valve stem for the amount of up and down movement required to open and close the valve. An advanced design employing two camshafts in which the use of rockers is entirely dispensed with is shown in Fig. 417. Here the cams operate directly on the valve stem except for the intervention of a small piston and guide used to prevent side thrust on the stem of the valve. The arrangement shown in Fig. 417 is a less expensive but ingenious system employed on certain popular light cars. It will be seen that only one camshaft is used, and also that a single spindle or shaft mounted above the camshaft is used to carry the rockers for both inlet and exhaust valve operation. The rockers take the form of bell cranks.

The silent and efficient operation of valve gear is dependent to a large extent on its proper lubrication and all up-to-date designs provide for a copious flow of oil over the cam and rocker gear. Copper pipes leading from the oil pump deliver oil at pressure to all the vital points. Where a rocker spindle such as that shown in Fig. 418 is employed the spindle itself is hollow and oil fed to the interior from whence it passes to the rocker bearings through small holes in the sides of the spindle. Skew gears particularly need a continuous supply of oil as the oil tends to be flung off in operation. Lack of adequate lubrication accounted for many of the failures in the early experiments with shaft drives using skew and bevel gears, when the principles of lubrication for these parts was not properly understood.

Tappet Clearance.—With all the systems of poppet valve operation it is always necessary to leave a minute clearance between the end of the valve stem and the tappet or other device in contact with it. This clearance occurs, of course, only when the valve is seated and the " hump " of the cam is not operating on the target. It is necessary to provide it in order to make certain that the valve is seating properly. The smallest amount of, say, one or two thousandths of an inch is all that is required to ensure this, but owing to the uneven expansion of cylinder block, valve stem, tappet, etc. under the different temperatures of these parts when working, and to the difference in the coefficient of expansion of the different metals of which these various parts are composed, it is necessary to adjust this gap to a value which usually varies from nil to as much as eight-thousandths of an inch, according to the make and type of engine. The adjustment is usually carried out by means of a screwed head to the tappet and is retained by means of a locking nut. Other methods include the use of packing shims between valve stem and tappet and the employment of an eccentric mounting for the fulcrum of the rocker arm. In Figs. 414 and 416 the point where the tappet clearance is measured is denoted by the letter A.

The Sleeve Valve—The sleeve valve, as its name implies, is a hollow tube or sleeve interposed between the cylinder walls and the piston. In the Knight double-sleeve engine, which is probably the best known and most successful of this class, there are two such sleeves. These slide up and down between the piston and the containing cylinder walls, in the upper part of which are cut the inlet and exhaust ports. The ports are covered and uncovered by the action of the sleeves, these having holes or ports cut in them which register at the right moment with those in the cylinder. Fig. 421 shows this type of engine in section. A is the outer, and B the inner sleeve, while I is the inlet port and E the exhaust port on the opposite side of the cylinder.

The sleeves are operated by means of small connecting rods, C and D, working from a small-throw crankshaft. This shaft rotates at half engine speed and corresponds to the camshaft of an ordinary engine. Details of the shaft are shown at S in Fig. 422. The connecting rods produce a vertical motion in each sleeve of about 1 inch, but as the cranks are set at different angles to each other the sleeves do not at all times move in the same direction. For instance, one may be moving upwards while the other is travelling downwards, thus ensuring a rapid uncovering of the ports.

The cylinder head used with the double sleeve valve engine is peculiar in that it extends well into the cylinder barrel so that the sleeves pass between it and the sides of the barrel. Three rings similar to piston rings and a wide junk ring (J), are fitted so as to prevent any leakage of gases between the head and the sleeves. Without the necessity of accommodating poppet valves the combustion chamber can be made very nearly to the ideal spherical shape. The top of the piston is made slightly concave, while the head itself approaches the hemispherical. The lower circumference of the head comes level with the upper edges of the ports.

Before explaining the action of the sleeves it must be mentioned that there are several possible combinations of movement of the sleeves and location of the openings which will give the required opening and closing of the ports. However, the two ports in the inner sleeve are usually placed at the same level while the exhaust port in the outer sleeve is placed either higher or lower than the inlet port in the same sleeve. The arrangement shown here is that in which the exhaust opening is lower. The action of the sleeves is then as follows: at the commencement of the intake stroke both the inlet and the exhaust ports are slightly open and both sleeves are descending. The outer sleeve has just begun its descent, but the inner one is about to finish its downward movement; therefore, at the moment the outer sleeve is

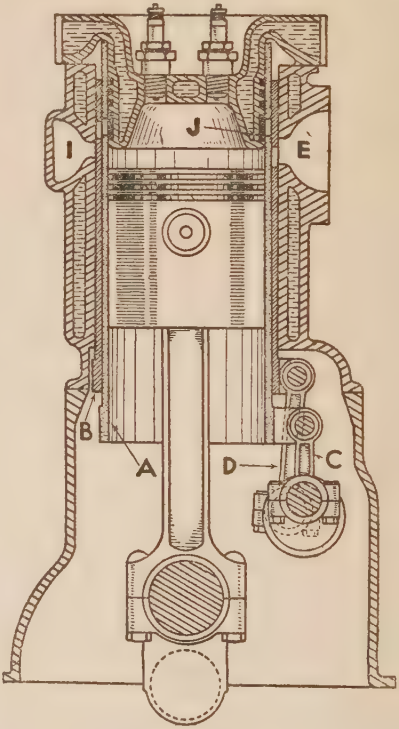


FIG. 421.—Sectional view of a Double-sleeve Valve Engine.

higher than the inner one. As the piston descends the inlet port in the outer sleeve rapidly overtakes that in the inner sleeve. The inner sleeve now reaching the limit of its downward stroke commences to rise, so that the space between the bottom edge of the port in the outer sleeve and the top edge of the port in the inner sleeve increases very rapidly, until the two ports exactly coincide and are opposite the induction port in the cylinder itself. The exhaust port, which we mentioned was still open at the commencement of the intake stroke, closes soon after the piston commences its descent by reason of the outer sleeve descending also. The top edge of the exhaust port in this sleeve meets the bottom edge of the cylinder port and so cuts off the exhaust opening for the rest of the intake stroke. By the time the piston reaches bottom dead centre the inner sleeve has risen until the inlet port is almost closed. A few more degrees of the crank and the bottom edge of the port in the inner sleeve meets the bottom of the cylinder head, that is the edge of the junk ring. For the rest of the compression stroke therefore, both inlet and exhaust ports are closed while the two sleeves rise together. Firing now occurs and the inner sleeve descends during the firing stroke and the outer one rises. The exhaust opens when the bottom edge of the exhaust port in the inner sleeve comes below the junk ring, the port in the outer ring rising and coming opposite to that in the inner one at the same time. The two sleeves descend together giving the full opening during the exhaust stroke.

Advantages of Sleeve Valves.—The chief merits of the sleeve valve type of engine are its silence and freedom from the need of adjustment. Hence its use in the more expensive and luxurious type of car. The Knight sleeve-valve engine was employed in Daimler cars for many years. The power output of the sleeve-valve engine is not quite so great as that obtainable with the more conventional poppet valve engine, hence it has shown no prominence in racing. However, with a high-powered car this is not of such great account and is offset by the increased silence and the freedom from the periodical tappet adjusting, valve-grinding, etc., associated with poppet valves. The reason for the inferior power output can be attributed to the need for restricting the reciprocating motion of the sleeves to a small amount and therefore limiting the port openings. Some of the chief difficulties met

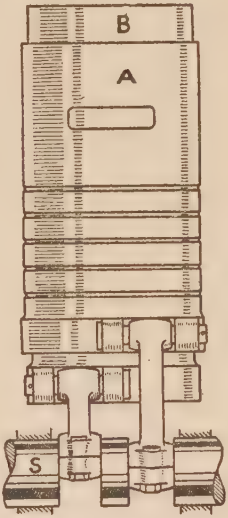


FIG. 422.—Details of the sleeves and operating mechanism.

with in the manufacture of this class of engine occur in the making of the sleeves which must be designed to avoid fracture or distortion under working conditions. The question of adequate lubrication of the sleeves, and, on the other hand, the prevention of gumming and high oil-consumption are other important points.

Valve Timing.—Whatever type of valves are employed, whether poppet, sleeve, or rotary, they must be timed to open and close at certain pre-determined moments during the cycle of operations. Fortunately, the correct timing is decided by the manufacturers, and except for the unlikely event of a timing chain breakage there should be no need to disturb the setting during the life of the car. If, however, the timing should slip it is usually possible to re-set it by means of the marks placed against certain teeth on the timing wheels for that purpose. The manufacturers' instruction book will help here. It is not usually such a difficult matter as might be imagined, since as the positions of the cams on the camshaft are all fixed, it is only necessary to get the valves of one cylinder (usually the front one), timed correctly, when the correct timing of all the others follows automatically.

A timing diagram is shown in Fig. 423. It will be noticed that the valves do not open and close exactly at the commencement or termination of each stroke of the piston, but that they open or close "early" or "late," as the case may be. For example, the inlet valve does not shut immediately the piston reaches the bottom of the intake stroke, but remains open while the piston commences to rise on the compression stroke. It has been found that at high engine speeds, owing to the inertia of the incoming gases they will continue to pour into the cylinder after the piston has commenced its upward move, therefore the valve is left open a fraction of a second longer so as to get as much of the explosive vapour into the cylinder as possible. In the same way the exhaust valve opens early—that is, before the end of the firing stroke. The reason here is that for the last 30 or 40 degrees of rotation of the crankshaft the piston only moves a very small distance, so that very little power is wasted by letting the exhaust gases escape before the piston quite reaches the bottom of its stroke, while the early opening allows the burnt products of the explosion considerably more time in which to leave the cylinder and so make room for the next supply of petrol vapour.

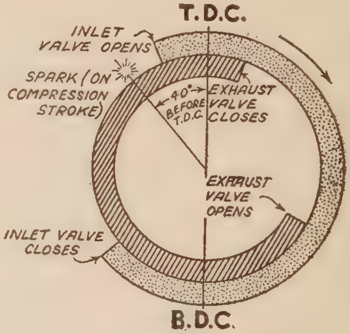


Fig. 423.—Valve-timing Diagram.

The diagram shows that the inlet valve opens several degrees before the piston reaches the top of the exhaust stroke and closes considerably after the end of the intake stroke. The exhaust valve opens about 45 degrees before the end of the power stroke and closes after the inlet stroke has commenced. This is quite a normal timing arrangement with a fast-revving modern car engine. The time during which both inlet and exhaust valves are open together, at the end of the exhaust and the beginning of the inlet stroke, is known as the " overlap." With some engines there is no overlap, the exhaust valve closing before the inlet commences to open. The degree of overlap decided upon, and also the exact periods during which the valves shall remain open depends on many factors, including the size and shape of the cylinder (especially the relation between the bore and stroke, the position of the sparking plug, and the shape of the combustion head). Also the speed at which the engine runs and the shape of the manifolds, etc.

The idea of overlap is connected with the extractor effect produced by the exhaust gases rushing down the exhaust pipe. In doing so their velocity is so great that a partial vacuum is created in the cylinder if the exhaust valve is left open. This helps to suck in the fresh mixture. The inlet valve opens early, of course, in order to take full advantage of this. A section of an engine with several degrees of overlap is shown in Fig. 424. It will be noticed that the piston is near the top of its stroke and that both valves are open.

In the ordinary way it is not possible to alter the relative timings of the valves of a car, since, as already explained, all the cams are mounted on one shaft (except in the case of twin camshafts). Therefore the only alteration that can be made is to make the whole operation of opening and closing all the valves to occur earlier relative to the position of the crankshaft, or else later. If by any chance a mistake has been made in re-timing an engine, the symptoms will be as follows: If the timing is too early it will cause back-firing; there will be spluttering and popping in the carburettor and possibly smoke from it. If the timing is late a sluggish engine and overheating will result.

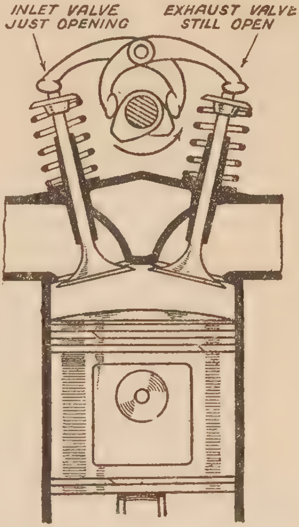


FIG. 424.—Cut-away drawing of an O.H.V. Engine Valve Overlap.

VALVE - REMOVER.—A metal tool which, by strongly compressing the valve spring, enables the valve to be lifted readily out of its fitting.

VALVE SEATING.—The area ground out of the cylinder with which the valve makes close contact when it is in the " closed " position.

VALVE SPRING. — A helical spring, the function of which is to keep the cylinder valves firmly on their seatings, thus preventing the leakage of the gases within the cylinder.

VANADIUM STEEL.—Steel containing small percentages of the rare metal, vanadium. It has a high-tensile strength, and is sometimes used as a car constructional material.

VAPOUR.—The readily condensible emanation thrown off by a liquid, as, for instance, petrol vapour.

There is, however, little difference between a vapour and a gas, the latter being a vapour which exists at a temperature much above its condensation point, as, for example, oxygen gas which is the vapour of liquid oxygen, a liquid boiling at the extremely low temperature of —182·5° C.

VAPOURISER.—In a restricted sense this term applies to special devices which, using the exhaust heat of the engine, serve to vapourise heavy fuels such as paraffin, naphtha, etc.

VAPOUR PRESSURE. — The pressure which the vapour of a liquid exerts upon the surrounding atmosphere or upon the walls of the vessel containing it.

The vapour pressure of a liquid varies with its temperature, the higher the temperature of the liquid, the greater its vapour pressure.

At any given temperature the higher the vapour pressure of a liquid the more volatile that liquid is. Petrol, benzole, and other motor spirits are all liquids possessing fairly high vapour pressures.

VASELINE. — A proprieatry name, now in common use, applied to one of the high-boiling distillation products of crude petroleum. Universally used as a grease lubricant, either alone or in conjunction with graphite, or other substances.

VENT HOLE.—A term usually signifying the minute hole which is drilled through the filler-cap of the fuel tank for the purpose of admitting to the tank interior the necessary amount of air required to occupy the space of the departing fuel. If this arrangement were not made, the fuel would cease to flow.

Vent holes, of course, are not provided in the filler-caps of tanks which serve a pressure-feed supply of fuel.

VENTURI TUBE.—A device employed in some early forms of carburettors. It consisted of a small metal tube, the bore of which was narrowed in the centre. At this latter portion of the tube a needle valve was inserted. This served to control the supply of air which the engine sucked through the tube and, also, the amount of petrol vapour which was drawn up from a reservoir of the fuel below.

In general, any tube having a reduced bore at some part of it may be termed a Venturi tube.

VERNIER COUPLING.—Name given to a method of securing fine differences in the ignition timing of an engine, a finely adjustable coupling being provided between the armature drive of the magneto and the drive from the engine.

VICE.—Term applied to denote any type of workshop or garage screw-press used for the purpose of holding objects tightly whilst work is being performed on them.

From the French, *vis*, a screw.

VISCOSITY. — The degree of thickness or stickiness of a liquid. The term is usually, though not necessarily, restricted to lubricating oils and similar thick liquids.

VISE.—See *Vice*.

VITRIOL.—The popular name for the strong sulphuric acid (" Oil of Vitriol ") which, when diluted, forms the electrolyte of the accumulator.

VOITURETTE.—An old term of French origin signifying a two-seater car of low horse-power. Now obsolete.

VOLATILITY.—Applied to liquid fuels, this term denotes the readiness with which they evolve vapour at any given temperature. For ordinary internal-combustion engines, fairly volatile liquid fuels are, of course, essential.

The term " lightness " is also used in connection with a liquid fuel to describe its volatility.

VOLT.—The unit of electrical pressure. It is defined as the electro-motive force which, when applied to a conductor or circuit having a resistance of one ohm, causes a current of 1 ampere to flow in it.

After *Alessandro Volta* (1745-1826).

VOLTMETER.—An instrument for measuring the voltage or electrical pressure of a circuit.

A voltmeter is most useful for detecting short-circuits among the car wiring. Such instruments are made in a variety of different patterns.

V-TYPE ENGINE.—Name given to an engine whose cylinders are set opposite one another in the shape of a V at an angle of between 45 and 90 degrees.

VULCANISATION.—The union of sulphur with rubber by means of heat. By this process rubber acquires varying degrees of hardness, at the same time retaining its elasticity.

The term is often applied, though perhaps less correctly to processes involving the application of heat and pressure, locally or otherwise, to rubber articles such as tyres, etc., thus enabling a repair to be made. Practically, the process is one of rubber welding.

VULCANISER.—Name given to a portable apparatus which, by the application of heat and pressure, enables repairs to be made to rubber articles.

VULCANITE.—A form of hard rubber made by heating india-rubber with sulphur under considerable pressure. It can be obtained in many varying colours.

Articles of vulcanite are incorporated into many car fittings, etc. Steering-wheels are sometimes covered with a vulcanite layer of one kind or another.

W

WASHER.—A term which usually denotes a flat ring of metal or of other material which, being slipped over the bolt, is placed between the nut and the surface against which the latter is screwed, thus increasing the gripping action and the tightening effect of the nut.

Washers are also used for insulating purposes.

WATT.—The unit of electrical power. It equals work performed at the rate of one joule per second. 746 watts equal 1 horse-power.

The " wattage " of an electrical circuit is estimated by multiplying its amperage by its voltage. Thus, for instance, a source of electrical power providing 10 volts at 5 amps. is a 50-watt source.

After *James Watt* (1736-1819).

See *Joule.*

WATT-HOUR.—The commercial unit of electrical work, used in connection with power motors, etc.

A watt-hour equals the work performed by a current of 1 ampere flowing for 1 hour between two points in a circuit having a potential difference of 1 volt.

One watt-hour is equal to 3,600 joules.

See *Joule.*

WELDING.—It is far from being common knowledge that welding can be usefully employed for such unexpected purposes as increasing the diameter of a shaft which has been accidentally turned too small in a lathe or for building up a damaged key-way in a hardened steel shaft.

Work of this kind is a development that has resulted from recent important advances in electric welding technique and its value to the amateur mechanic is, of course, very considerable.

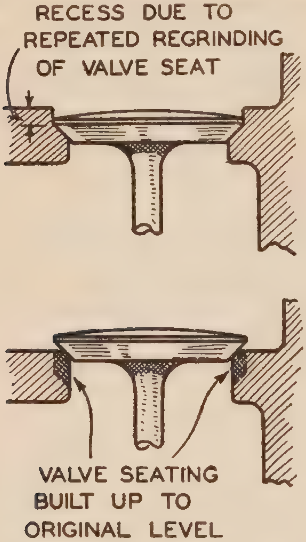

RECESS DUE TO REPEATED REGRINDING OF VALVE SEAT
VALVE SEATING BUILT UP TO ORIGINAL LEVEL

FIG. 425.—Pocketed valve seatings can cheaply and accurately be built up by welding and made even better than new.

Perhaps it will be as well to explain for a start that this " building up " work must not be confused with the Barimar metallurgical process for filling scores. This latter is specially applicable to such jobs as filling blow-holes in castings of all kinds and making good the damage to a cylinder bore which is done when a gudgeon pin is not properly located and cuts deep longitudinal channels in the polished surface of the barrel.

When these " building up " processes are employed, whatever the nature of a repair may be, the new metal that is added is identical in analysis, tensile strength and ultimate hardness to the parent material. The operator is able to choose and employ the process which is ideal for the job.

A Typical Job.—A typical repair is to an axle half-shaft which has been damaged owing to the hub having worked loose. It arrives at Lamb's Conduit Street or one of the branch factories with the key-way damaged and the taper scored and shouldered. The first job is to test the shaft and record its characteristics before the welding operation begins. Then the old key-way is completely filled and a new skin of steel is applied to the entire length of the taper. Machining follows and finally heat treatment.

In a case like this, of course, the machine shop needs the hub shell because the taper within it is almost certain to be damaged. Frequently all that it will require will be a skim in a lathe, the axle end being left a shade oversize to ensure a perfect fit. When, however, this is not practicable because it interferes with the refitting of races, the hub is also built up and machined to original size. In a case of this kind it will be noted that the owner of the car from which the shaft has been taken saves not only the cost of a new half-shaft but that of a hub shell.

Whilst writing of axle shafts it may be mentioned that very frequently they get damaged by unsuitable types of wheel puller being employed for removing the hub to get access to the brake shoes. Sometimes the end of the shaft is burred so that the nut cannot be run on and often the thread is ruined by the pointed end of the wheel puller slipping out of the centre hole in the shaft and cutting a deep channel down it. In the ordinary way the method of repair is a simple building-up operation, but in a very serious case it is sometimes better to cut off the threaded portion and to replace it with a new piece of steel.

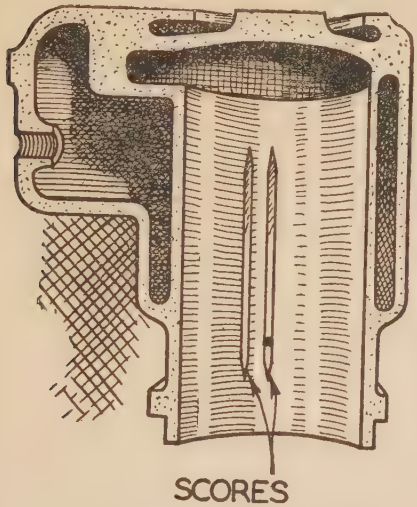


FIG. 426.—Scored cylinders (spelling heavy oil consumption) can now be filled at small cost.

A Ticklish Repair.—A week or two ago a job of this kind had to be done to a crankshaft. The flywheel in this case was secured by a deeply sunken nut which really could have been removed only with a robust and close-fitting box spanner. The amateur mechanic who had been doing the dismantling of the engine had not possessed a suitable tool and in battling with the nut had so damaged it that no tool would budge it. In addition the end of the thread on the shaft was blurred and was not accessible for machining. After examination it was decided to cut off the end of the crankshaft complete with the flywheel and to weld on a new piece, the flywheel tapered hole being cleared by drilling and boring, and it was quite an inexpensive operation which saved the cost of a new shaft.

Water-pump shafts are often a source of considerable trouble on old cars owing to neglect of the packing resulting in deep scores forming round that part of the shaft which passes through the gland. The rectification of this trouble is a very simple welding operation and if required any bearings on the shaft can be left a little oversize thus saving the cost of new bushes.

Treatment of Splines.—The building-up of splines and squares provides another example of the value of this new "plastic" branch of metal surgery. The most familiar trouble is for a mechanic to find when dismantling a gearbox that one short section of a long spline has become badly worn and shouldered thus making the gearbox noisy and the gears difficult to change. In such instances the *modus operandi* is to fuse new steel deeply into the worn surfaces and then to re-machine the affected parts. It makes a cheap and thoroughly satisfactory job particularly as a very hard deposited metal will be used thus making the shaft more suited for its job than when it was new.

Similar processes to those used for work of this kind are available for building-up chipped gear teeth and for correcting wear or damage in female parts such as the splines in the boss of a differential bevel wheel.

The most popular of all the building-up operations is the restoration of valve seats. The trouble which has to be corrected will no doubt be familiar to every reader of this handbook. The too frequent grinding-in of the valves, the heat and the hammering action, gradually reduce the level of the seatings until the valves when closed are "masked"—the seatings being recessed a $\frac{1}{16}$ inch or more instead of being flush with adjacent machined surfaces. The remedy until recently was to cut new seatings and to fit a set of valves with oversize heads. This was not satisfactory, however, from many points of view. There was interference with the gas-flow owing to there being a ridge in the mouth of the port, and the special set of valves, of course, was expensive. Then loose-valve seat inserts were introduced and proved satisfactory for relatively low-speed engines. They were sometimes liable, however, to work loose in high-revving engines, and could not be fitted in many small units owing to there being an insufficiency of metal for cutting a thread to receive them.

Valve Seatings.—The modern plan when valve seatings become sunken is to employ a special welding process which fuses new, hard iron into the surface of the seatings and then to machine them precisely to their original shape. In the course of the operation the old valve guides can be extracted and new standard guides installed, so that the engine is restored to its full efficiency.

Here it may be mentioned that enthusiastic amateur engine-tuners sometimes have a mishap when cutting away part of the valve guides which obstruct the ports and when polishing the insides of ports. Cases sometimes occur when a cutting tool of some kind has broken right through the walls of a port into the water-jacket. It is an easy building-up operation to correct such an accident and the cost is quite trifling. Further, the ports can be polished

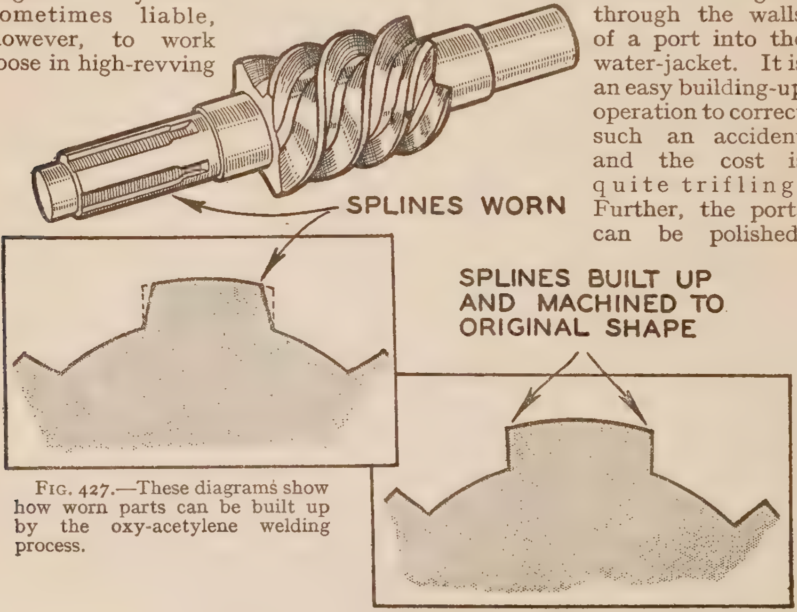


Fig. 427.—These diagrams show how worn parts can be built up by the oxy-acetylene welding process.

WHEELBASE.—Term used to denote the distance between the centres of the front and rear wheels of a car or other vehicle. It is usually expressed in feet and inches.

WHEEL DISC.—A circular cover of metal or other material which serves to enclose the wire spokes of a wheel.

WHEEL GAUGE.—See *Track Measurement.*

WHINE.—A term which describes the characteristic sound produced by the revolutions of two engaging gear wheels whose teeth are worn so that they mesh too deeply.

WHITE LEAD.—Chemical formula: $PbCO_3$. Lead carbonate. A white powder which is almost insoluble in water. Mixed with drying oils, etc., it is sometimes used as a joint-making and sealing composition to prevent leakages in petrol pipes, etc.

WHITE METAL.—A silver-like alloy composed chiefly of lead and antimony, but often containing varying percentages of zinc, bismuth, iron and copper. It is used as a groundwork for silver and nickel plating and, also, for the construction of accessories and fittings.

A similar alloy is known by the name of *Anti-Friction Metal*, which see.

WHITWORTH THREADS.—Name given to a standardised range of screw-threads first introduced in 1841 by Sir Joseph Whitworth (1803-1887) for purposes of engineering construction.

The Whitworth standard is still employed—it is now called the "British Standard Whitworth" (B.S.W.)—but these threads, being relatively coarse ones, have been replaced for many purposes by finer ones, such as the British Standard Fine (B.S.F.) and the British Standard Automobile (B.S.A.)

WICK CARBURETTOR.—A long obsolete type of carburettor in which the capillary action of a wick was utilised to furnish a supply of petrol vapour to the engine.

WIDTH INDICATORS.—Term applied to devices, usually comprising a ball mounted on the end of a vertical rod, which are fitted to the front wings of a car in order to give an indication to the driver of the safe "manœuvring-width" of the car.

Width indicators are usually employed on cars in which it is difficult or impossible for the driver to see the tip of the near-side wing from his position in the driving-seat.

WINDING.—Term used to denote the turns of wire which, wound on some supporting structure, enter into the construction of many electrical devices, as, for instance, the windings of a coil, a magneto, transformer or dynamo.

WINDSCREEN.—A glass screen which is fitted to cars immediately before the driver's seat in order to give protection against wind, rain and bad weather. Early cars were never fitted with windscreens.

WINDSCREEN WIPER.—A device which causes a rubber squeegee to be drawn backwards and forwards over a portion of the windscreen in front of the driver's seat, thus keeping the line of vision unobscured in rainy weather. Automatic windscreen wipers usually work by engine suction, although some patterns are electrically driven.

WINDSCREEN WIPERS.—The hand-operated type of screen wiper is now obsolete, its place having been taken by the mechanically operated types. Of these there are two kinds—the pneumatic or "suction" type, and the electrically driven wiper. The chief drawback of the suction wiper is that its speed varies with the degree of throttle opening. Thus, when the throttle is closed, as when the engine is ticking over in traffic, the wiper will speed up in operation and swish from side to side very rapidly. When the throttle is open fairly wide, as when travelling fast or accelerating, the wiper slows down. Of course, the speed of operation is adjustable, but it is not always convenient or safe to make adjustments while driving. With the electric wiper the action is powerful and the speed constant, in fact there is not usually any means of varying the speed of operation, this being decided upon by the manufacturers and the motor designed accordingly.

There is a third type of mechanical wiper which is not very common and which is driven after the manner of a speedometer, that is by means of a flexible rotating cable driven from the tail shaft of the gear box.

The Suction-operated Type.—The principle of the pneumatic wiper is the utilisation of the suction of the engine in the induction pipe leading from the carburettor to the inlet ports to work a small suction pump connected to the wiper blade. Probably the best known type is the double piston type illustrated in Figs. 428-429. Leading from the induction pipe of the engine is a narrow rubber tube which connects to the instrument. The size of the inlet passage is controlled by a tapered adjuster screw. By screwing this right down the passage can be completely blocked and the wiper stopped. When the wiper is working it is unscrewed a turn or so according to the speed required. The inlet pipe leads to a simple slide-valve arrangement. There are two positions for the slide valve. In one position the inlet passage is connected with the narrow pipe A, which communicates with the left-hand side of the wiper cylinder. In the other position it connects with the opposite pipe B, which leads to the opposite end of the cylinder. The cylinder contains a double piston the two halves of which are connected by a rack. The forward and backward movement of the rack is converted into rotary motion at the wiper blade by means of a sector wheel or pinion. In Fig. 428 the pistons are shown almost at the limit of their travel to the left. At this moment the right-hand piston comes up against the end of a rod connected with the slide valve (the rod can just be seen between the right side of the sector and the piston). It pushes the rod to the left and this flips the slide valve over to the right. Although the mechanism of the slide valve is not shown here, it is similar in principle to that of the wiper shown in Figs. 432 and 433, which will be described next. Its action is similar to the familiar tumbler switch used for the domestic electric lighting. Moving the rod compresses a small coil spring until the slide to which it is attached suddenly jumps over to the right. The face of the slide has a channel cut in it which then connects the intake passage with the right-hand transfer pipe.

The suction wiper shown in Figs. 332 and 433 employs a paddle device attached direct to the wiper-blade spindle and so obviates the use of a rack and pinion. The paddle operates in an airtight chamber semi-circular in section and somewhat more compact than the cylinder of the previous model. One notable feature of this instrument is that it requires only one fixing hole in the windscreen or

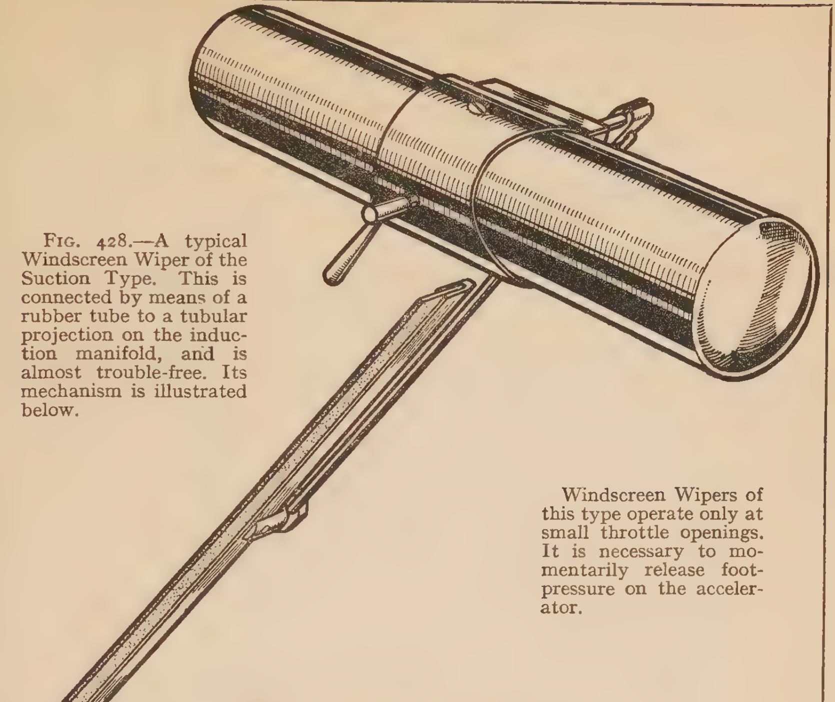


FIG. 428.—A typical Windscreen Wiper of the Suction Type. This is connected by means of a rubber tube to a tubular projection on the induction manifold, and is almost trouble-free. Its mechanism is illustrated below.

Windscreen Wipers of this type operate only at small throttle openings. It is necessary to momentarily release foot-pressure on the accelerator.

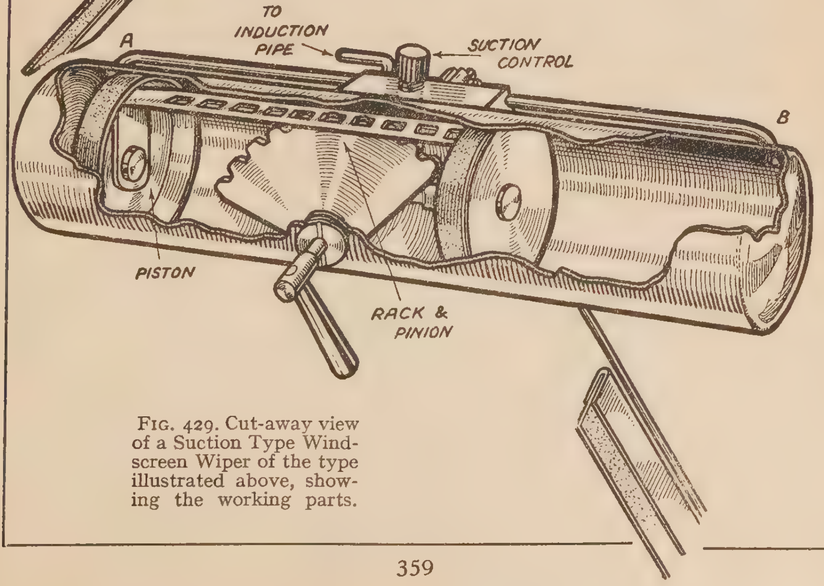
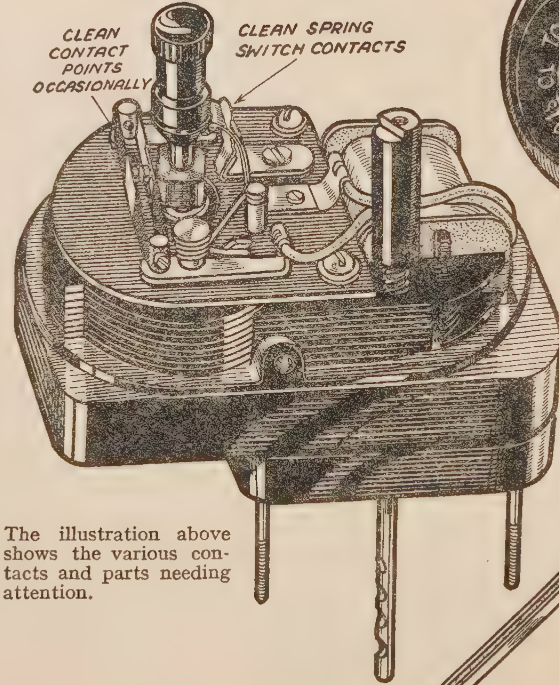

A
TO INDUCTION PIPE
SUCTION CONTROL
B
PISTON
RACK & PINION

FIG. 429. Cut-away view of a Suction Type Windscreen Wiper of the type illustrated above, showing the working parts.


CLEAN CONTACT POINTS OCCASIONALLY
CLEAN SPRING SWITCH CONTACTS

The illustration above shows the various contacts and parts needing attention.

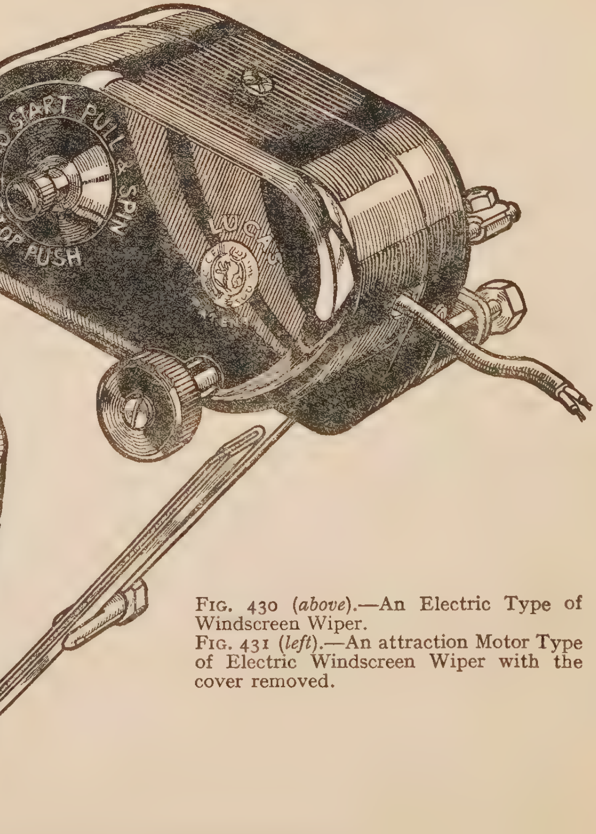

TO START PULL & SPIN
TO STOP PUSH
LUCAS

FIG. 430 (*above*).—An Electric Type of Windscreen Wiper.

FIG. 431 (*left*).—An attraction Motor Type of Electric Windscreen Wiper with the cover removed.

windscreen frame. This is made possible by lengthening the spindle bush. It is only necessary to drill a hole for this to pass through and the instrument is then held in position by tightening the nut on the bush. The inlet passage communicates with port A via a screw for controlling the suction and for stopping the wiper when not in use.

When the slide valve, which consists of a small metal quadrant with a channel cut in its face, is over to the left it connects the port A with the port B. B communicates with the left side of the main suction chamber through a passage which emerges at D. The suction of the engine evacuates the air from this side of the suction and so sucks the paddle over to the left. This action rotates the wiper arm to the left at the same time. When the paddle reaches the end of its movement in this direction the little pegs on the front end of the spindle engage in a spring-loaded trip catch, which knocks the slide valve over to the right, thus transferring the suction of the engine to the right-hand side of the chamber.

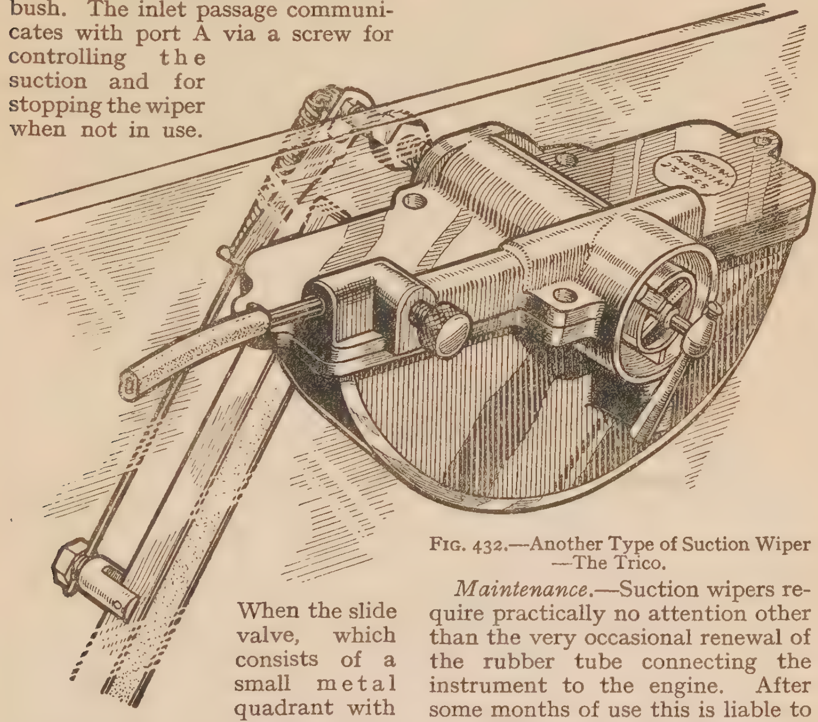


FIG. 432.—Another Type of Suction Wiper—The Trico.

Maintenance.—Suction wipers require practically no attention other than the very occasional renewal of the rubber tube connecting the instrument to the engine. After some months of use this is liable to get perished, and as a new piece can be obtained for a few pence, it is false economy to continue with a pipe which may let you down on the road. The pipe is most liable to disintegrate near the end where it joins the induction pipe of the engine. This is due to the heat. However, if the original pipe is of generous length it is often possible to prolong its useful life by cutting off the last inch or two, which may have become rotten, and reconnecting it to the induction pipe.

A wiper which does not seem very strong in action although the connecting tube is quite sound, may need a little oil to make the pistons air tight. This can often be injected into the instrument without taking it to pieces.

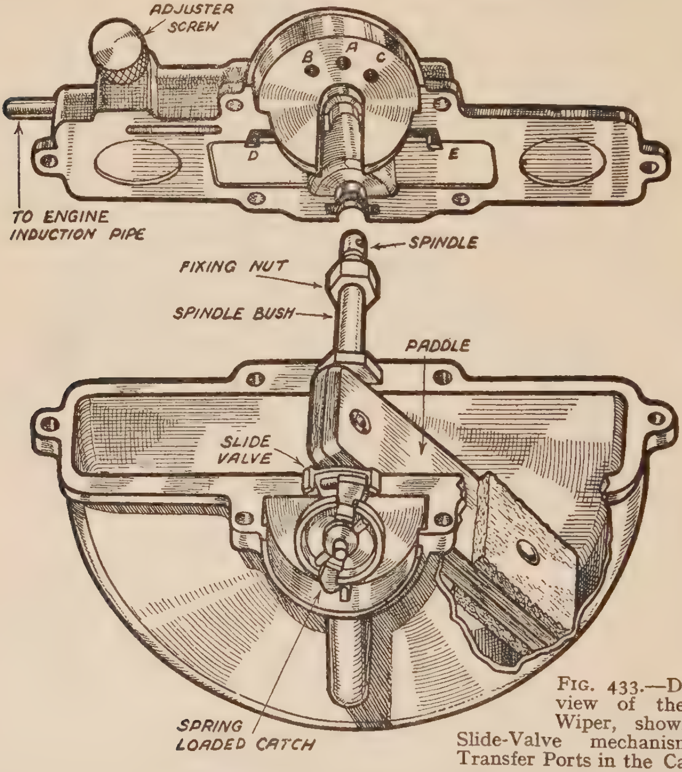


FIG. 433.—Dissected view of the Trico Wiper, showing the Slide-Valve mechanism and Transfer Ports in the Casting.

Suction Wipers and Carburation.—In the ordinary way the amount of air sucked into the engine by the windscreen wiper should be insufficient to make any noticeable difference to the running of the engine. However, if the rubber pipe is perished and leaks, it may happen that the wiper still functions, although a considerable amount of air is also leaking in through the holes in the pipe. In this case the extra air may be quite sufficient to cause difficult starting owing to the weakening of the mixture. As the wiper still works, the owner may not think to look for the cause of the trouble in this direction. The obvious remedy is to renew the tubing as soon as it shows signs of perishing.

Electric Screen Wipers.—Electrically-driven wipers are of two main types, the difference being in the kind of motor employed. The most expensive and the more powerful type contains a small electric motor of the usual commutator type, and is self-starting. No attention is required during the first year or two's use, since the bearings and driving gear are packed with grease by the makers during assembly. All working parts are enclosed to prevent the ingress of dirt. There is usually, however, a small hole in the cover to allow the escape of any slight traces of gas produced by the action of the brushes. After prolonged use the mechanically minded owner may feel tempted to inspect the works, when the gearing may be greased, if necessary, and the commutator and brushes cleaned with a non-fluffy rag dipped in petrol.

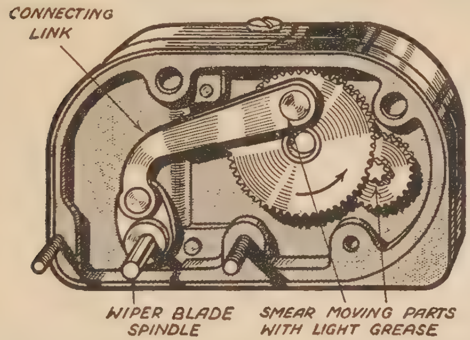


FIG. 434.—The Drive Mechanism of the Electric Wiper shown by Fig. 430, as revealed when the back cover is removed.

The other type of electric wiper employs an attraction motor. A very good example is the Lucas instrument illustrated in Figs. 430 and 434. With this type of motor it is necessary to give it a start by rotating the spindle.

WIRE WHEEL.—A type of road-wheel, containing wire spokes, built on the principle of the cycle wheel. It is employed on some light cars. The wire wheel attains its stability by means of the distributed tension of the spokes.

WING NUT.—A nut which possesses two " wings " or projections which enable it to be manipulated by the fingers instead of with a spanner.

Wing nuts are used for clamping purposes in many car fittings and accessories.

WINGS.—Name given to the pressed metal mudguards which cover the car wheels and which serve to prevent road-dirt being thrown up by the latter.

Synonym : *Sidewings.*

WIPE SPARK.—A term which is sometimes applied to the spark which passes between the contact-breaker of a magneto or induction coil.

The term is an exceedingly misleading one, inasmuch as the make-and-break action of both these instruments is not a wiping but distinctly a hammer-like movement.

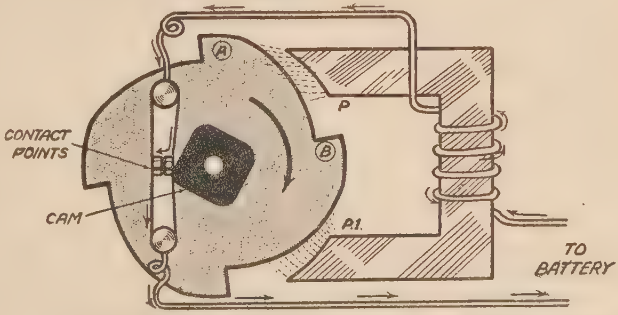


FIG. 435.—Diagram explaining the action of an Electric Wiper.

WIRELESS.—It is now common knowledge that the number of cars to be fitted with wireless-receiving equipment has rapidly increased since the 1933 Show. There are still many people who say that car-radio is dangerous and undesirable, but it appears by no means improbable that wireless sets will in future be fitted as standard on all but the lowest-priced cars.

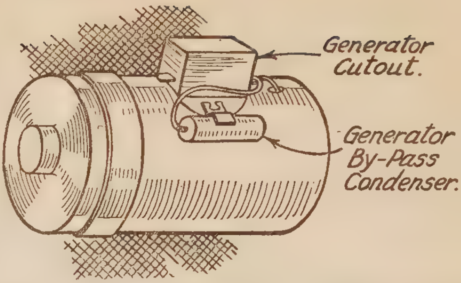


FIG. 437.—A fixed condenser should be connected across the terminals of the dynamo to prevent electrical interference.

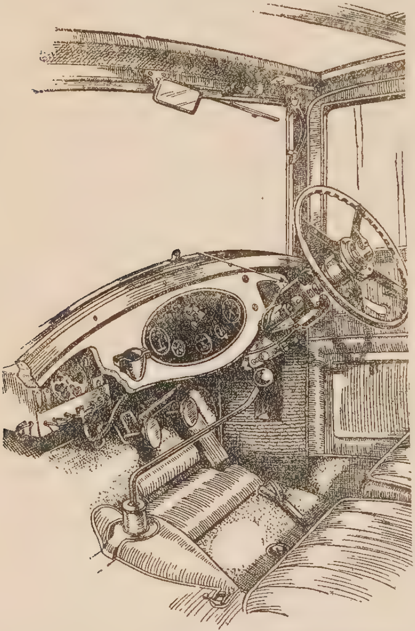


FIG. 436.—Typical layout of car radio set.

The purpose of this section is not, however, to discuss the merits or de-merits of car-radio, but to point out some of the practical aspects of the question of installing a wireless set for broadcast reception in the motor car. At first sight it might appear that the title at the head of this page is an incorrect one, and that no problems worth mentioning should in fact, exist. The fallacy of such an idea is quickly proved by taking, say, an ordinary portable receiver in the car and attempting to use it whilst the car is running. Although the set is known to be in perfect condition, and though it might give excellent results when the car is stationary, it will be found that nothing but a terrific and continuous " buzzing " or " crackling " sound can be heard once the engine has been started.

Ignition Interference.—The reason for this is that the ignition system acts as a miniature transmitter, and every spark produced at the plug-points or in the contact-breaker, produces a corresponding noise in the loud-speaker. It is not usually very difficult to overcome this trouble by fitting noise suppressors in the main lead to the distributor, and in series with each high tension lead to the plugs, and suitable suppressors are made by a number of firms. Actually, the suppressors consist of nothing more complicated than ordinary fixed resistances of the non-inductive type, and they are made with screw contacts so that they form extensions to the distributor and plug terminals. The general form taken by the suppressors can be seen in some of the accompanying illustrations. Incidentally, it might be mentioned that any wireless experimenters who wish to try car-radio without buying these special components can use ordinary 1-watt wireless resistances of about 50,000 ohms. for the initial trials. The most suitable value of resistance varies to a certain extent with the make and type of car, but once the proper resistances have been found the correct running of the engine will not be affected in the least.

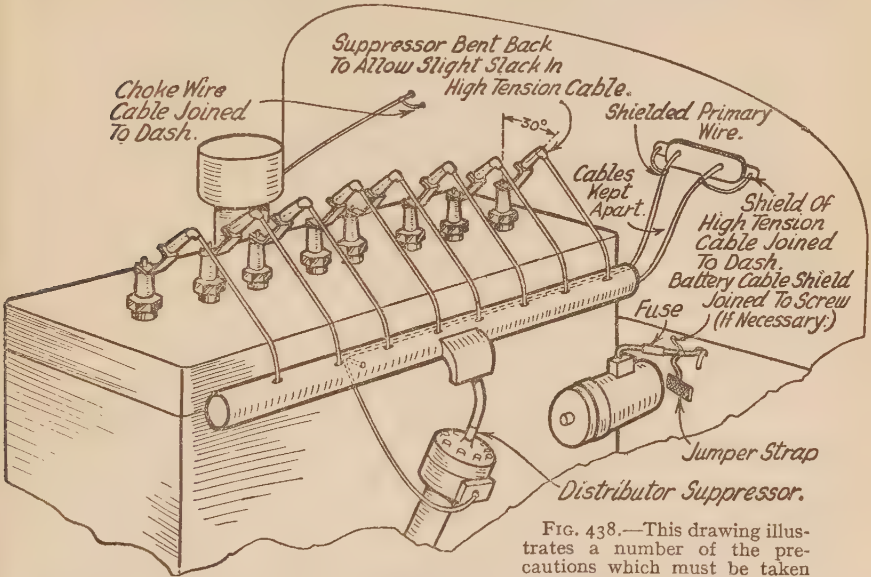

Suppressor Bent Back
To Allow Slight Slack In
High Tension Cable.
Choke Wire
Cable Joined
To Dash.
30°
Shielded Primary
Wire.
Cables
Kept
Apart.
Shield Of
High Tension
Cable Joined
To Dash.
Battery Cable Shield
Joined To Screw
(If Necessary.)
Fuse
Jumper Strap
Distributor Suppressor.

FIG. 438.—This drawing illustrates a number of the precautions which must be taken in order to prevent electrical interference with the wireless receiver.

Dynamo Noises.—Another source of interference with wireless reception in a car set is the dynamo, especially if the brushes are at all dirty, or if sparking is taking place due to the commutator being dirty, or to any similar reason. In any case, it is best to look to the brushes and commutator to make sure that everything is in order, but even after that it will generally be found that a fixed condenser must be wired in parallel with the output terminals. This condenser should have a capacity of about 4 mfds. and must be mounted as near as convenient to the terminals to which it is joined. For use with cars having a single-wire electrical system, there are special condensers made which have a metal container, this being in contact with one electrode of the condenser. The method of fitting, by means of a small metal strap, is shown in Fig. 437.

Loose Metallic Parts.—Even after taking the precautions so far dealt with it is quite likely that there will still be some interference with reception, this being due to vibration of metal body panels, loose metallic parts, and lack of screening between the set and the car (assuming that

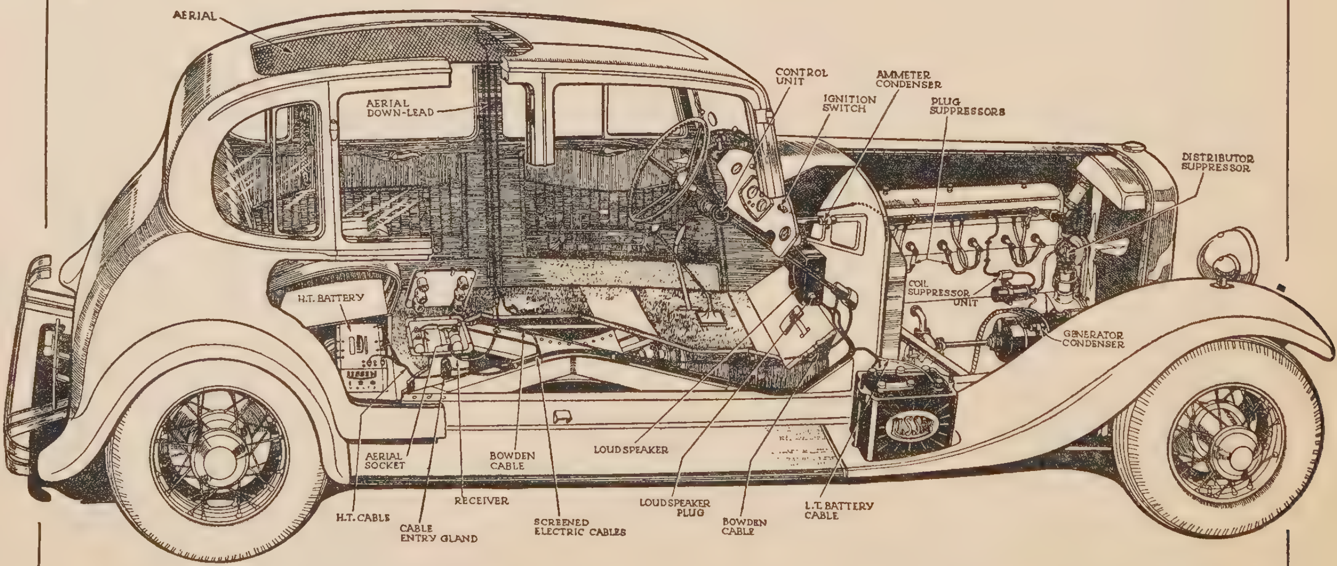

AERIAL
AERIAL DOWN-LEAD
CONTROL UNIT
IGNITION SWITCH
AMMETER CONDENSER
PLUG SUPPRESSORS
DISTRIBUTOR SUPPRESSOR
H.T. BATTERY
COIL SUPPRESSOR UNIT
GENERATOR CONDENSER
AERIAL SOCKET
BOWDEN CABLE
LOUDSPEAKER
H.T. CABLE
RECEIVER
CABLE ENTRY GLAND
SCREENED ELECTRIC CABLES
LOUDSPEAKER PLUG
BOWDEN CABLE
L.T. BATTERY CABLE

FIG. 439.—Schematic diagram showing the position of the various units of the Lissen car-radio installation.

a special car-radio receiver is not being used). The first trouble can entirely be overcome by thoroughly encasing the set in a metallic screen which is " earthed " to the chassis, whilst the second is obviated by connecting all loose parts, such as carburettor controls, strangler wires, and the like, to the chassis at any points where they pass through holes; the point is shown in Fig. 438.

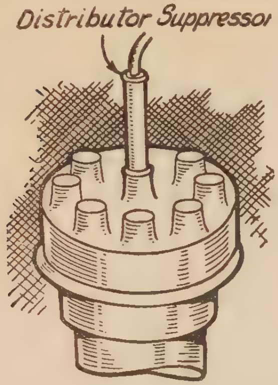


FIG. 440.—A suppressor resistance should be fitted to the centre terminal of the distributor.

Aerial and Earth Connections.—After the various sources of interference have been located and the trouble corrected it is necessary to consider the most suitable aerial and earth arrangements. A frame aerial, such as is used in most portable sets, is obviously quite unsuitable, partly because it is " direction al " and partly because it cannot function correctly in a closed car (or even in an open one for that), because of the heavy screening and damping effect which the metal bodywork has upon it. An " indoor " aerial is unsuitable for similar reasons, and the only real solution rests with the use of a wire running round the edge of the roof on the outside, or between the framework and the fabric covering. Another idea which has recently been introduced in commercial form however, takes the form of two sheets of metal gauze. Each of these is placed between two sheets of rubber and attached to the underside of a running board ; the two " aerials " are connected together and to the set.

Although it is obviously impossible to make a direct connection to earth an effective " capacity earth " is provided by the chassis of the car. Consequently it is only necessary to take a wire from the earth terminal on the set to a chassis bolt.

The Power Supply.—Another problem of car-radio is that of obtaining the necessary high- and low-tension power supplies. Low-tension can easily be derived from the car battery, but a high-tension battery would be both cumbersome and expensive in maintenance for the multi-valve set which must be employed in order to secure truly satisfactory reception. Various forms of converters have therefore been evolved by means of which voltages of about 200 at a current of 40 milliamps or so can be obtained from the lighting battery. The converters really consist of an electric motor and D.C. dynamo housed together in one casing. In other words, there is a double armature on a common shaft, this functioning in both sections of the combination machine. Other H.T. supply units consist of make-and-break mechanism connected to a step-up transformer, the arrangement being almost identical with that used for coil-ignition purposes. The output from the transformer is A.C. and is therefore rectified by means of a metal rectifier, and then smoothed in the usual manner.

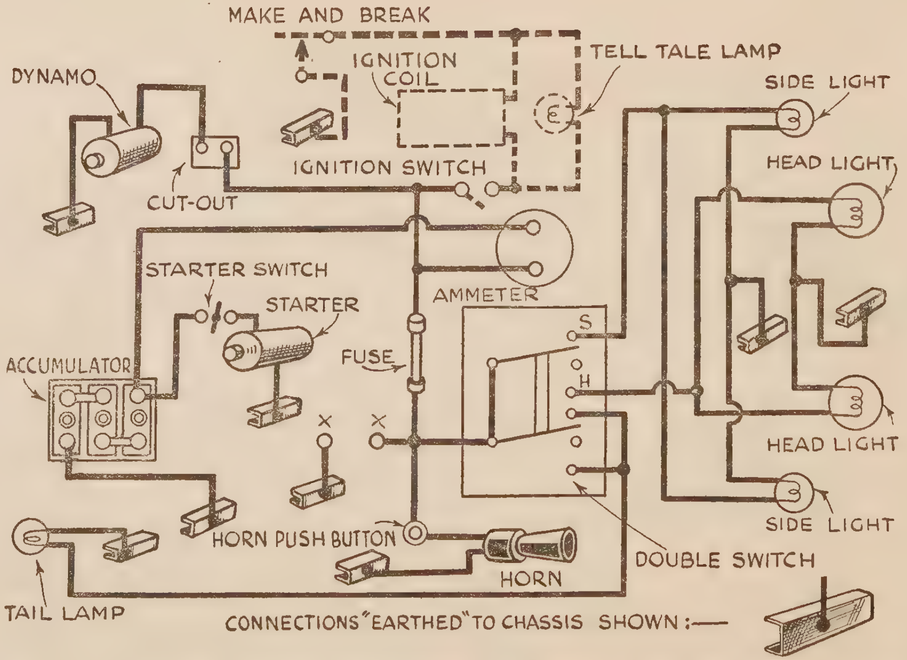

MAKE AND BREAK
IGNITION COIL
TELL TALE LAMP
DYNAMO
CUT-OUT
IGNITION SWITCH
SIDE LIGHT
HEAD LIGHT
STARTER SWITCH
STARTER
AMMETER
S
H
ACCUMULATOR
FUSE
X
X
HEAD LIGHT
SIDE LIGHT
HORN PUSH BUTTON
HORN
DOUBLE SWITCH
TAIL LAMP
CONNECTIONS "EARTHED" TO CHASSIS SHOWN :—

FIG. 441.—A complete Car-wiring arrangement. The circuit is that used on modern cars. The Ignition circuit is shown in broken lines.

Both types of supply units described are fitted into metal boxes, with flanges, which are sunk through a hole in the floorboards, as shown in a sketch in this section. No matter which type of unit is employed there is essentially an extra drain on the accumulator, and this point must be considered.

Receiver Considerations.—The final, though by no means the least important, problem concerns the receiver itself. As the aerial is necessarily of low efficiency the set must be sensitive, and at the same time it must provide sufficient volume for comfortable listening. Added to these considerations the set certainly must be provided with a completely effective automatic volume-control device. If this is not provided signals will constantly vary in strength, as the car passes buildings, walls and other cars. A.V.C. has been well-nigh perfected during the last few months, so that there is now no great difficulty in producing a receiver which will not suffer from the effects of fading. In respect of the actual circuit arrangement to be used for the car-radio set, there are two schools of thought; one favours the superheterodyne and the other, the multi-H.F. style of receiver. In most instances, however, it will be found that the former is preferable, although there is at least one very successful car-radio outfit on the market in which the circuit is of the " straight " H.F. kind.

The matter of finding a " home " for the set scarcely exists in a large car, and when using one of the many special car receivers, since the receiver proper can be fitted behind the dashboard. From there it is connected with a control panel (generally attached to the steering column) by means of flexible control rods. The knobs are placed in such positions that they come readily to hand, so that with very little practice the driver can easily tune in without taking his eyes off the road. In a small car the question of accommodation is a serious one, and cannot be solved, unless one is prepared to reduce the seating accommodation. It is usually necessary to attach the set to the scuttle on the passenger side of the front seat, and this means either that the passenger seat cannot be used or (if two bucket seats are fitted) it must be slid back, in which case one-half of the back seat is practically useless for its normal purpose.

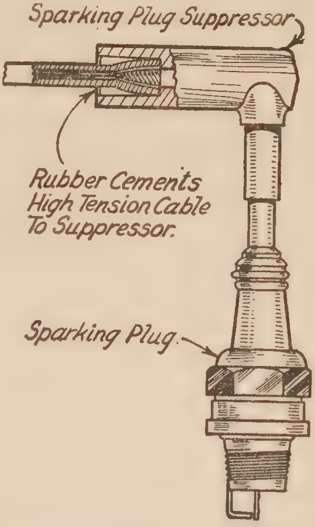


FIG. 442.—Showing a sparking plug suppressor of the type referred to in the text.

The loud-speaker can generally be mounted on, or just below, the dashboard in a car of moderate size, but in the small car it must generally be placed in a rear corner, or else attached to the inside of the roof.

WIRING.—The system of electric wires and cables which connect up the various electrical instruments and components of a car, thus providing the necessary complete electrical circuits.

WOBBLE.—Term used to denote a side-to-side movement of the car wheels occurring at average speeds. See *Shimmy*.

WORK.—Used in a scientific sense, work is said to be done on a body or mass of material when the latter is moved by a force acting upon it. The amount of work performed is estimated by multiplying together the force applied and the distance which the body is moved in the direction of the force. Various units of work are employed in engineering calculations. See *Power*.

WORKING STROKE.—See *Ignition Stroke*.

WORM.—A spiral thread, so-called on account of its winding or serpent-like nature.

In engineering construction, the term is applied to a small metal shaft on which an endless screw is cut.

WORM GEAR.—A form of gearing comprising a gear-wheel whose teeth mesh with a worm or endless screw. Worm gearing is frequently used for the final drive in the back axle of a car.

WROUGHT IRON.—The purest commercial form of iron. It is obtained by removing practically the whole of the carbon from pig-iron.

Wrought iron is tough. It can be rolled out into sheets, drawn into wire, made into plates, nails, etc. At one time it constituted an important constructional material of the automobile industry, but nowadays its place is being taken by pressed steel. See *Cast-iron*.

X

XYLENE. — Chemical formula : $C_6H_4(CH_3)_2$. Name given to any of three hydrocarbon liquids (or to a mixture of them) having the same percentage composition. The xylenes occur to some extent in commercial benzole but more especially in the fuel naphtha used for heavy engines.

XYLONITE. — A celluloid - like material coloured by the admixture of various pigments, first introduced commercially in 1867. It is used in the construction of certain car fittings, steering-wheel heads, etc.

Y

Y-ALLOY.—A high-grade aluminium alloy used in some electrical components. It was first worked out at the National Physical Laboratory at Teddington, Middlesex. It contains about 93 per cent of aluminium, the remainder being copper, nickel, and magnesium.

Y-alloy has a high electrical conductivity and a good tensile strength.

YARD.—An English measure of distance. One yard equals 12 feet, 36 inches, or 0·91 of a metre.

From the Anglo-Saxon, *Gyrd*, a rod or measure.

Z

ZINC.—A bluish-grey metal forming an important constituent of dry batteries. It is also used for galvanising iron.

Taking silver as 100, good-quality zinc has an electrical conductivity of about 29. Pure zinc melts at 418°C. At a temperature of 200°C. zinc becomes very brittle and can be broken up into a fine powder.

ZIRCONIUM. — A hard grey metal possessing a very high melting-point.

Incorporated with steel in small amounts, it increases enormously the hardness of the metal. Unfortunately, zirconium products are not readily obtainable. In America, however, much work has been done on Zirconium steels.

USEFUL TABLES

TROUBLE TRACING TABLES

(Compiled by the Proprietors of Sternol)

SYMPTOMS	CAUSE	REMEDY
Loss of Compression	Warped, scored or pitted valve head	True up in lathe. Grind to seat and polish. If very bad, renew valve
Loss of Compression	Valve seat warped or pitted	Use re-seating reamer. Clean and grind valve to seat properly
Loss of Compression	Valve stem bent, binding or stuck in guide or covered with scale	Straighten in lathe if bent. Make free with paraffin and clean with emery cloth
Loss of Compression	Loose gudgeon pin has scored cylinder wall	Fasten gudgeon pin securely. Replace cylinder if groove is deep or weld score
Loss of Compression	Piston rings loose. Lack of spring. Loose in grooves, scored, worn or broken. Slots in line	Fit new rings if worn or broken. If slots in line turn slots apart 180°. Eliminate wear by oiling
Hissing or blowing	Leak in threads, insulation or packing of sparking-plug, compression taps or valve caps	Replace insulation or packing rings if defective. Screw down tighter
Loss of Power	Leak in carburettor or manifold joints. Cracks or blow-holes in intake manifold	Tighten up all joints, replacing jointing if necessary. Stop all air leaks
Pre-ignition	Carbon deposits or sharp edges in combustion chamber	Smooth out roughness, scrape or dissolve carbon
Pre-ignition	Piston head covered with carbon. Rarely cracked	Scrape or dissolve carbon. Use " carbon oil." Replace piston if cracked
Overheating	Water-circulating pump not working	Dismantle and adjust
Overheating	Too rich or too weak a mixture	Adjust petrol level in float chamber or size of jet

SYMPTOMS	CAUSE	REMEDY
Overheating	May not be caused by defect in engine but by the binding of the brake shoes	See that the shoes are clear of the drum when brakes are off
Overheating	Cylinder wall scored by poor lubrication causing excessive friction	Grind out bore. Fit new piston. Use good oil
Overheating	Tight piston rings. Carbon in grooves. Insufficient opening in ring, causing binding in cylinder	Remove carbon from rings and grooves. File slot if necessary
Overheating	Scored or rough crankshaft journals or burned bearings. Sprung crankshaft. Defective lubrication	Smooth up journals and re-metal bearings. Refit. Straighten crankshaft. Clean all oil channels. Use good oil
Overheating	Crank or main bearings adjusted too tight	Slacken off bolts and insert extra distance piece
Overheating	Insufficient oil in sump. Poor lubrication. Oil dirty.	Adjust oil level. If oil is dirty wash out with paraffin and put in fresh supply of good oil
Overheating	Water pipes or radiator tubes clogged with sediment or scale	Dissolve foreign matter if possible and clean out water system
Sharp knock each explosion. " Pinking "	Carbon deposits in combustion chamber	Scrape out or dissolve carbon. Grind valves if necessary. Clean thoroughly. Use good oil
Sharp metallic knock	Bolts holding cylinder casting loose	Tighten bolts
Metallic knock, rattle or grinding noise	Timing gears loose on shaft. Out of time. Teeth worn or mesh too deep	Fasten securely. Retime. Replace with new if necessary. Eliminate wear by using good oil

SYMPTOMS	CAUSE	REMEDY
Clicking knock	Worn contour of cams	Put in new camshaft if necessary
Slight knock. Irregular valve action	Loose or worn camshaft bearing causing end play	Adjust properly or replace. Clean out oil holes and grooves
Sharp metallic knock, especially on full load	Gudgeon pin worn, loose in piston	If only loose fasten securely; otherwise replace pin and bushes
Sharp knock and click	Connecting rod big end or main bearing bolts loose	Tighten bolts and nuts, using cotter pins or locking washers
Intermittent knock	If hard to locate look to cooling fan.	Take up end-play if necessary, and lubricate well with good oil
Knock on hills	Big end bearing worn or too much side play	Take up bearings if side play excessive; renew bearings
Grinding or squeak	Piston binding in cylinder, due to underlubrication	Refit piston and rings. Replace with new if badly scored. Use good oil
Dull hammering	Piston worn or cylinders oval	If slight, fit new piston rings. If bad, regrind cylinder and fit new piston
Regular thump	Main bearing too loose. Too much end-play	Refit bearings
Rough grinding noise	Main bearing ball-race too tight or balls pitted. Ball-race loose in housing or on shaft	Replace ball-races—and use only good quality oil
Pounding and rattling	Engine base loose on beds	Tighten all bolts and nuts
Bubbles in water in radiator when running	Cracked cylinder-head or walls; faulty gasket	Weld crack and regrind, or if too bad, replace cylinder; renew gasket

TROUBLE TRACING TABLES—*Concluded*

SYMPTOMS	CAUSE	REMEDY
Valve does not close	Valve spring weak or broken. Carbon or scale on seat or valve stem. Broken cotter	Put in new spring. Scrape and grind valve to seat properly. Clean. Renew cotter
Insufficient valve lift.	Valve cam contour worn, or too much clearance between valve and tappet	Replace with new camshaft. Adjust tappets. Use good quality oil
Wrong valve timing	Camshaft sprung or twisted	Straighten. Make true or replace
Wrong valve timing	Camshaft drive gear loose on shaft. Broken or worn teeth	Time properly. Righten. Replace with new gears

IGNITION SYSTEM TROUBLES

SYMPTOMS	CAUSE	REMEDY
Misfiring	Loose terminals. Chafed insulation causing short - circuits. Broken H.T. cable inside insulation	Tighten. Re-insulate. Replace
Misfiring	Insulation of Spark Plug oil - soaked. Electrode loose in shell. Dirty plugs	Clean or replace. Tighten
Engine refuses to stop when ignition switched off	Broken magneto earth wire	Replace
No spark	Sparking plug. No gap or too wide	Set points $\frac{1}{32}$ in. apart
No spark	Oil-soaked mica insulation. Insulation cracked. Heavy deposit of carbon inside sparking plug	Replace. Remove carbon. Replace cracked parts. Clean

MAGNETO

SYMPTOMS	CAUSE	REMEDY
Weak spark	Magneto weak. Condenser punctured (rare)	Return to makers for repair
No spark	Brushes not making contact	Strengthen springs or renew brush if wear excessive
No spark	Points not operating. Stuck or broken spring	Clean. Renew spring
No spark	Points too close. Dirty or burned out	Clean thoroughly. Set properly. Renew if necessary
Cannot control spark	Contact-breaker ring sticks	Remove and clean bearing
Spark does not fire charge	Armature out of time with points	Re-time properly
Noisy	Bearings worn. Magneto driving gear loose	Replace. Tighten
Engine misfires	Collecting or distributing brush broken or oily	Clean or replace
Engine misfires	Distributor segments worn	Secure even bearing
Engine misfires	Contact-breaker points pitted. Out of adjustment	Clean. Re-set properly
Engine misfires	Magnets loose on pole pieces	Tighten screws
Misfiring	Fibre bushing binding in contact lever (Bosch)	Ease slightly

WATER-COOLING SYSTEM TROUBLES

Water flow impeded	Internal passages clogged. Filled with scale or sediment. Air pockets	Dissolve and clean out. Open petcock to remove air
Water flow impeded	Swollen rubber washer or gasket. Dents or kinks in piping or hose. Inner walls of hose rotted	Replace. Straighten

SYMPTOMS	CAUSE	REMEDY
Water escapes	Leaky tubes or piping. Pump stuffing-box or cover leaks	Stop all water leaks. Repack stuffing-box glands
Water will not circulate or faulty circulation	Worn vanes in pump (centrifugal type). Worn gears (gear type). Sheared driving pin or key	Replace with new. Fit new pin or key

OIL SYSTEM TROUBLES

SYMPTOMS	CAUSE	REMEDY
No oil as sight-feed	Pump air-bound. Feed pipe clogged. No oil	Prime pump with oil. Clean. Replenish
Irregular oil feed	Dirty filter screen. Worn pump parts	Clean. Replace
Improper oil feed	Clogged ball check valves. (Plunger pump only)	Clean. Make sure balls seat tightly
Oil feeds wrongly, but pump O.K.	Clogged oil pipe or sight feed discharge filled with waste	Clean out thoroughly
Oil level indicator registers wrongly	Indicator clogged or stuck. Pointer bent float loose on stem	Make free. Straighten. Fasten in proper place
Engine carbonises quickly	Too thin or poor oil	Use good quality oil
Engine cranks hard. Heats too quickly	Tight bearings. Insufficient oil feed	Oil supply faulty. Increase level in troughs if necessary
Engine power decreases when hot	Oil is too poor to seal properly under heat	Use good oil
Bearings heat, yet not too tight	Clogged oil passages to bearings	Clean. Use oil that leaves no sediment
Overheated cylinders	Manifolds to troughs clogged. Too thin or too low-grade oil	Clean out. Use only good quality oil
Excessive oil consumption	Leaky joints in crankcase pump or piping. Worn piston rings. Poor oil	Re-make joints. In recent tests certain oils proved very poor

DECIMAL EQUIVALENTS OF MILLIMETRES

m/m.	*Inches*	*m/m.*	*Inches*	*m/m.*	*Inches*	*m/m.*	*Inches*
20·5	·80708	40·5	1·59448	60·5	2·38188	80·5	3·16928
21·	·82677	41·	1·61417	61·	2·40157	81·	3·18897
21·5	·84645	41·5	1·63385	61·5	2·42125	81·5	3·20865
22·	·86614	42·	1·65354	62·	2·44094	82·	3·22834
22·5	·88582	42·5	1·67322	62·5	2·46062	82·5	3·24802
23·	·90551	43·	1·69291	63·	2·48031	83·	3·26771
23·5	·92519	43·5	1·71259	63·5	2·49999	83·5	3·28739
24·	·94488	44·	1·73228	64·	2·51968	84·	3·30708
24·5	·96456	44·5	1·75196	64·5	2·53936	84·5	3·32676
25·	·98425	45·	1·77165	65·	2·55905	85·	3·34645
25·5	1·00393	45·5	1·79133	65·5	2·57873	85·5	3·36613
26·	1·02362	46·	1·81102	66·	2·59842	86·	3·38582
26·5	1·04330	46·5	1·83070	66·5	2·61810	86·5	3·40550
27·	1·06299	47·	1·85039	67·	2·63779	87·	3·42519
27·5	1·08267	47·5	1·87007	67·5	2·65747	87·5	3·44487
28·	1·10236	48·	1·88975	68·	2·67716	88·	3·46456
28·5	1·12204	48·5	1·90944	68·5	2·69684	88·5	3·48424
29·	1·14173	49·	1·92913	69·	2·71653	89·	3·50393
29·5	1·16141	49·5	1·94881	69·5	2·73621	89·5	3·52361
30·	1·18110	50·	1·96850	70·	2·75590	90·	3·54330
30·5	1·20078	50·5	1·98818	70·5	2·77558	90·5	3·56298
31·	1·22047	51·	2·00787	71·	2·79527	91·	3·58267
31·5	1·24015	51·5	2·02755	71·5	2·81495	91·5	3·60235
32·	1·25984	52·	2·04724	72·	2·83464	92·	3·62204
32·5	1·27952	52·5	2·06692	72·5	2·85432	92·5	3·64172
33·	1·29921	53·	2·08661	73·	2·87401	93·	3·66141
33·5	1·31889	53·5	2·10629	73·5	2·89369	93·5	3·68109
34·	1·33858	54·	2·12598	74·	2·91338	94·	3·70078
34·5	1·35826	54·5	2·14566	74·5	2·93306	94·5	3·72046
35·	1·37795	55·	2·16535	75·	2·95275	95·	3·74015
35·5	1·39763	55·5	2·18503	75·5	2·97243	95·5	3·75983
36·	1·41732	56·	2·20472	76·	2·99212	96·	3·77952
36·5	1·43700	56·5	2·22440	76·5	3·01180	96·5	3·79920
37·	1·45669	57·	2·24409	77·	3·03149	97·	3·81889
37·5	1·47637	57·5	2·26377	77·5	3·05117	97·5	3·83857
38·	1·49606	58·	2·28346	78·	3·07086	98·	3·85826
38·5	1·51574	58·5	2·30314	78·5	3·09054	98·5	3·87794
39·	1·53543	59·	2·32283	79·	3·11023	99·	3·89763
39·5	1·55511	59·5	2·34251	79·5	3·12991	99·5	3·91731
40·	1·57480	60·	2·36220	80·	3·14960	100·	3·93700

STANDARD BRASS THREAD

Diameter Inches	*Threads per Inch*	*Depth of Thread, Inches*	*Core Diam. Inches*	*Tapping Size Inches*
1/8	26	·0246	·0758	No. 47
1/4	26	·0246	·2008	„ 6
3/8	26	·0246	·3258	Q
1/2	26	·0246	·4508	29/64
5/8	26	·0246	·5758	37/64
3/4	26	—	·7008	45/64
7/8	26	·0246	·8258	53/64
1	26	·0246	·9508	61/64
1 1/8	26	·0246	1·0758	1 5/64
1 1/4	26	·0246	1·2008	1 13/64
1 1/2	26	·0246	1·4508	1 29/64

BRITISH STANDARD FINE

Diameter	*Threads per Inch*	*Pitch Inches*	*Depth of Thread*	*Core Diam. Inches*	*Diameter of Tap Drill*
1/4	25	·0400	·0256	·1988	No. 7
5/16	22	·0455	·0291	·2543	G.
3/8	20	·0500	·0320	·3110	O.
7/16	18	·0556	·0356	·3664	U.
1/2	16	·0625	·0400	·4200	27/64
9/16	16	·0625	·0400	·4825	31/64
5/8	14	·0714	·0457	·5335	35/64
11/16	14	·0714	·0457	·5960	19/32
3/4	12	·0833	·0534	·6433	21/32
13/16	12	·0833	·0534	·7058	18 mm.
7/8	11	·0909	·0582	·7586	49/64
15/16*	11	·0909	·0582	·8211	21 mm.
1	11	·1000	·0640	·8719	7/8
1 1/8	9	·1111	·0711	·9827	63/64
1 1/4	9	·1111	·0711	1·1077	1 7/64
1 3/8	8	·125	·0800	1·2149	1 7/32
1 1/2	8	·125	·0800	1·3399	1 11/32
1 5/8	8	·125	·0800	1·4649	1 15/32
1 3/4	7	·1429	·0915	1·5670	40 mm.
1 7/8*	7	·1429	·0915	1·6920	1 45/64
2	7	·1429	·0915	1·8170	1 53/64
2 1/8*	7	·1429	·0915	1·9420	1 61/64
2 1/4	6	·1666	·1067	2·0366	52 mm.
2 3/8*	6	·1667	·1067	2·1616	55 mm.

*The Committee recommend that these sizes be dispensed with.

WHITWORTH STANDARD PIPE THREADS

Formula
$$\begin{cases} N = \text{number of threads per inch} \\ \text{Depth of thread} = \dfrac{\cdot 64}{N} \end{cases}$$

Pipe Diameters							
Pipe Size Nom. Inside	*Approx. Outside*	*Threads per inch*	*Depth of Thread*	*Gauge Diam.*	*Position of Gauge Diam.*	*Minimum Length of Thread*	*Tap Drill Size*
1/8	13/32	28	·0230	·383	5/32	3/8	21/64
1/4	17/32	19	·0335	·518	3/16	7/16	29/64
3/8	11/16	19	·0335	·656	1/4	1/2	37/64
1/2	27/32	14	·0455	·825	1/4	5/8	23/32
5/8	15/16	14	·0455	·902	1/4	5/8	51/64
3/4	1 1/16	14	·0455	1·041	3/8	3/4	59/64
7/8	1 7/32	14	·0455	1·189	3/8	3/4	1 1/16
1	1 11/32	11	·0580	1·309	3/8	7/8	1 11/64
1 1/4	1 11/16	11	·0580	1·650	1/2	1	1 1/2
1 1/2	1 29/32	11	·0580	1·882	1/2	1	1 3/4
1 3/4	2 5/32	11	·0580	2·116	5/8	1 1/8	1 31/32
2	2 3/8	11	·0580	2·347	5/8	1 1/8	2 13/64
2 1/4	2 5/8	11	·0580	2·587	11/16	1 1/4	2 27/64
2 1/2	3	11	·0580	2·960	11/16	1 1/4	2 13/16
2 3/4	3 1/4	11	·0580	3·210	13/16	1 3/8	3 3/64
3	3 1/2	11	·0580	3·460	13/16	1 3/8	3 9/32
3 1/4	3 3/4	11	·0580	3·700	7/8	1 1/2	3 17/32
3 1/2	4	11	·0580	3·950	7/8	1 1/2	3 25/32
3 3/4	4 1/4	11	·0580	4·200	7/8	1 1/2	4 1/32
4	4 1/2	11	·0580	4·450	1	1 5/8	4 9/32
4 1/2	5	11	·0580	4·950	1	1 5/8	..
5	5 1/2	11	·0580	5·450	1 1/8	1 3/4	..
5 1/2	6	11	·0580	5·950	1 1/4	1 7/8	..
6	6 1/2	11	·0580	6·450	1 3/8	2	..

WHITWORTH STANDARD HEXAGON NUTS AND BOLTS

Diam.	*Hexagonal Nuts*		*Thickness of Bolt Heads*	*Diam.*	*Hexagonal Nuts*		*Thickness of Bolt Heads*
	Across Flats	*Across Corners*			*Across Flats*	*Across Corners*	
	Inches				*Inches*		
⅛	·338	·390	·1093	2¾	4·18	4·82	2·4062
3/16	·448	·517	·164	2⅞	4·34	5·02	2·5156
¼	·525	·606	·2187	3	4·53	5·23	2·625
5/16	·601	·694	·2734	3⅛	4·69	5·41	2·7343
⅜	·709	·819	·3281	3¼	4·85	5·6	2·8256
7/16	·820	·947	·3828	3⅜	5·01	5·78	2·9531
½	·920	1·06	·4375	3½	5·17	5·98	3·0624
9/16	1·01	1·16	·4921	3⅝	5·36	6·19	3·1718
⅝	1·1	1·27	·5468	3¾	5·55	6·41	3·2812
11/16	1·2	1·38	·6016	3⅞	5·75	6·64	3·3906
¾	1·3	1·5	·6562	4	5·95	6·87	3·5
13/16	1·39	1·6	·7064	4⅛	6·16	7·11	3·6094
⅞	1·48	1·7	·7656	4¼	6·37	7·36	3·7046
15/16	1·57	1·82	·8203	4⅜	6·6	7·62	3·8271
1	1·67	1·93	·875	4½	6·82	7·88	3·9374
1⅛	1·86	2·15	·9843	4⅝	7·06	8·15	4·0469
1¼	2·05	2·36	1·0937	4¾	7·3	8·43	4·1562
1⅜	2·21	2·55	1·2031	4⅞	7·55	8·72	4·2656
1½	2·41	2·78	1·3125	5	7·8	9·01	4·375
1⅝	2·57	2·97	1·4128	5⅛	8·06	9·31	4·4844
1¾	2·75	3·18	1·5312	5¼	8·35	9·64	4·5926
1⅞	3·02	3·48	1·6406	5⅜	8·6	9·93	4·7031
2	3·15	3·63	1·75	5½	8·35	10·22	4·8124
2⅛	3·34	3·85	1·8523	5⅝	9·15	10·57	4·9218
2¼	3·54	4·09	1·9687	5¾	9·45	10·91	5·0312
3⅜	3·75	4·33	2·0781	5⅞	9·75	11·26	5·1406
2½	3·89	4·49	2·1875	6	10·	11·55	5·25
2⅝	4·05	4·67	2·2968				

BRITISH STANDARD AUTOMOBILE THREAD

Full Diam. Inches	*Threads per Inch*	*Pitch*	*Depth of Thread*	*Core Diameter*
$\frac{1}{4}$	26	·0385	·0246	·2007
$\frac{9}{32}$	26	·0385	·0246	·2320

The Engineering Standards Committee have adopted the British Association Standard for all sizes below ¼ in. and for ½ in. up to 1 in. British Standard Fine, excepting those amendments given in the above table.

SPARKING PLUG THREAD

(Same as International Metric System)

Pitch	1·5 mm.
Full Diameter	18·0 mm.
Effective Diameter	17·026 mm.
Core Diameter	15·889 mm.

INTERNATIONAL AND FRENCH STANDARD THREAD GAUGES

(Metric System)

$$\text{Formula}\begin{cases} p = \text{pitch} \\ d = \text{depth} = p \times {\cdot}64952 \\ f = \text{flat} = \dfrac{p}{8} \end{cases}$$

Diameter of Screw m/m.	*Pitch m/m.*	*Diameter at Root of Thread m/m.*	*Width of Flat m/m.*
3	0·5	2·35	·06
4	0·75	3·03	·09
5	0·75	4·03	·09
6	1·0	4·70	·13
7	1·0	5·70	·13
8	1·0	6·70	·13
8	1·25	6·38	·16
9	1·0	7·70	·13
9	1·25	7·38	·16
10	1·5	8·05	·19
11	1·5	9·05	·19
12	1·5	10·05	·19
12	1·75	9·73	·22
14	2·0	11·40	·25
16	2·0	13·40	·25
18	2·5	14·75	·31
20	2·5	16·75	·31
22	2·5	18·75	·31
24	3·0	20·10	·38
26	3·0	22·10	·38
27	3·0	23·10	·38
28	3·0	24·10	·38
30	3·5	25·45	·44
32	3·5	27·45	·44
33	3·5	28·45	·44
34	3·5	29·45	·44
36	4·0	30·80	·5
38	4·0	32·80	·5
39	4·0	33·80	·5
40	4·0	34·80	·5
42	4·5	36·15	·56
44	4·5	38·15	·56
45	4·5	39·15	·56
46	4·5	40·15	·56
48	5·0	41·51	·63
50	5·0	43·51	·63
52	5·0	45·51	·63
56	5·5	48·86	·69
60	5·5	52·86	·69

MANUFACTURERS' DIMENSIONS OF WHITWORTH STANDARD TAPS

Diameter	*Length of*			*Side of Square*
	Whole Tap	*Screw Part*	*Square Part*	
in.	*in.*	*in.*	*in.*	*in.*
1/32	1 1/2	5/8	3/16	..
3/32	1 5/8	3/4	3/16	..
1/8	1 3/4	7/8	1/4	..
5/32	1 7/8	7/8	1/4	..
3/16	2	1	5/16	..
7/32	2 1/8	1 1/16	5/16	..
1/4	2 1/4	1 1/8	3/8	..
5/16	2 1/2	1 1/4	7/16	5/32
3/8	2 3/4	1 1/2	1/2	7/32
7/16	3 1/4	1 3/4	1/2	9/32
1/2	3 1/2	2	9/16	5/16
9/16	3 3/4	2 1/8	9/16	5/16
5/8	4	2 1/4	5/8	3/8
11/16	4 1/4	2 3/8	11/16	3/8
3/4	4 1/2	2 1/2	3/4	7/16
13/16	4 3/4	2 5/8	3/4	7/16
7/8	5	2 7/8	13/16	1/2
15/16	5 1/4	3	13/16	1/2
1	5 1/2	3 1/4	7/8	5/8
1 1/8	6	3 1/2	1	11/16
1 1/4	6 1/2	3 3/4	1 1/8	13/16
1 3/8	7 1/2	4 1/4	1 1/8	13/16
1 1/2	8	4 3/4	1 1/4	1
1 5/8	8 1/2	5 1/4	1 1/4	1
1 3/4	9	5 1/2	1 3/8	1 1/8
1 7/8	9 1/2	5 3/4	1 3/8	1 1/8
2	10	6	1 1/2	1 5/16
2 1/8	10 1/2	6 1/4	1 1/2	1 3/8
2 1/4	11	6 3/4	1 5/8	1 1/2
2 3/8	11 1/2	7 1/4	1 5/8	1 5/8
2 1/2	12	7 3/4	1 3/4	1 5/8
2 5/8	12 1/2	8 1/4	1 3/4	1 3/4
2 3/4	13	8 3/4	1 7/8	1 3/4
2 7/8	13 1/2	9 3/4	1 7/8	1 7/8
3	14	10 3/4	2	2

METRIC SCREW THREADS

French and International Standard

(Larger Sizes)

Outside Diameter m/m	*Pitch m/m*		*Pitch Diameter m/m*	*Root Diameter m/m*	*Tap Drill m/m*
	French	*Internationl*			
18	2·5	2·5	16·38	14·75	15·00
20	2·5	2·5	18·38	16·75	17·00
22	2·5	2·5	20·38	18·75	19·00
24	3	3	22·05	20·10	20·5
26	3	..	24·05	22·10	22·5
27	..	3	25·05	23·10	23·5
28	3	..	26·05	24·10	24·5
30	3·5	3·5	27·73	25·45	25·5
32	3·5	..	29·73	27·45	27·5
33	..	3·5	30·73	28·45	28·5
34	3·5	..	31·73	29·45	29·5
36	4	4	33·40	30·80	31
38	4	..	35·40	32·80	33
39	..	4	36·40	33·80	34
40	4	..	37·40	34·80	35
42	4·5	4·5	39·08	36·15	36·5
44	4·5	..	41·08	38·15	38·5
45	..	4·5	42·08	39·15	39·5
46	4·5	..	43·08	40·15	40·5
48	5	5	44·75	41·50	42
50	5	..	46·75	43·50	44
52	..	5	48·75	45·50	46
56	..	5·5	52·43	48·85	49
60	..	5·5	56·43	52·85	53
64	..	6	60·10	56·20	56·5
68	..	6	64·10	60·20	60·5
72	..	6·5	67·78	63·56	64
76	..	6·5	71·78	67·56	68
80	..	7	75·45	70·91	71

Tyre Size Equivalents

(Approximate)

65	Millimetres	=2½ in.	650	Millimetres	=26 in.
80	,,	=3 ,,	700	,,	=28 ,,
85	,,	=3¼ ,,	750	,,	=30 ,,
90	,,	=3½ ,,	800	,,	=32 ,,
100	,,	=4 ,,	870	,,	=34 ,,
105	,,	=4¼ ,,	910	,,	=36 ,,
120	,,	=5 ,,	1010	,,	=40 ,,

A. S. M. E. STANDARD THREADS

(Formula same as U.S. Standard)

$$\text{Formula} \begin{cases} p = \text{pitch} = \dfrac{1}{\text{No. threads per inch}} \\ d = \text{depth} = p \times \cdot 64952 \\ f = \text{flat} = \dfrac{p}{8} \end{cases}$$

Nominal Size	*Outside Diameter Inches*	*Pitch Diameter Inches*	*Root Diameter Inches*	*Tap Drill Size*
0–80	·0600	·0519	·0438	56
1–56	·0730	·0614	·0498	55
64	·0730	·0629	·0527	54
72	·0730	·0640	·0550	53
2–56	·0860	·0744	·0628	51
64	·0860	·0759	·0657	50
3–48	·0990	·0855	·0719	48
56	·0990	·0874	·0758	47
4–32	·1120	·0917	·0714	48
36	·1120	·0940	·0759	46
40	·1120	·0958	·0795	45
48	·1120	·0985	·0849	43
5–36	·1250	·1078	·0889	42
40	·1250	·1088	·0925	40
44	·1250	·1102	·0955	39
6–32	·1380	·1777	·0974	38
36	·1380	·1200	·1019	36
40	·1380	·1218	·1055	35
7–30	·1510	·1294	·1077	33
32	·1510	·1307	·1104	32
36	·1510	·1330	·1419	31
8–30	·1640	·1423	·1207	30
32	·1640	·1437	·1234	30
36	·1640	·1460	·1279	29
40	·1640	·1478	·1315	29

A. S. M. E. STANDARD THREADS

(Concluded)

Nominal Size	*Outside Diameter Inches*	*Pitch Diameter Inches*	*Root Diameter Inches*	*Tap Drill Size*
9–24	·1770	·1499	·1229	30
30	·1770	·1553	·1337	29
32	·1770	·1567	·1364	28
10–24	·1900	·1629	·1359	28
28	·1900	·1668	·1436	26
30	·1990	·1684	·1467	24
32	·1900	·1697	·1494	23
12–24	·2160	·1889	·1619	19
28	·2160	·1928	·1696	17
32	·2160	·1957	·1754	16
14–20	·2420	·2095	·1770	14
24	·2420	·2149	·1879	10
16–18	·2680	·2319	·1966	8
20	·2680	·2355	·2030	4
22	·2680	·2385	·2090	3
18–18	·2940	·2579	·2218	1
20	·2940	·2615	·2290	A
20–16	·3200	·2794	·2388	C
18	·3200	·2839	·2478	F
20	·3200	·2875	·2550	G
22–16	·3460	·3054	·2648	T
18	·3460	·3099	·2738	R
24–16	·3720	·3314	·2908	M
18	·3720	·3359	·2998	N
26–14	·3980	·3516	·3052	O
16	·3980	·3574	·3168	P
28–14	·4240	·3776	·3312	R
16	·4240	·3834	·3428	S
30–14	·4500	·4036	·3572	U
16	·4500	·4094	·3688	V

WIRE AND SHEET METAL GAUGES

Number of Gauge	British Imperial Standard or English Legal Standard		American or Brown and Sharpe		Birmingham or Stubs Iron		Gold and Silver (Birmingham)		Lancashire Steel Pinion Wire	
	in.	*m/m.*	*in.*	*m/m.*	*in.*	*m/m.*	*in.*	*m/m.*	*in.*	*m/m.*
7/0	·500	12·70	..	..	..	..	..	..	..	..
6/0	·464	11·78	..	..	..	..	..	..	..	..
5/0	·432	10·97	..	..	..	..	..	..	..	..
4/0	·400	10·16	·46	11·68	·454	11·53	..	..	..	..
3/0	·372	9·44	·409	10·388	·425	10·787	..	..	..	..
2/0	·348	8·83	·364	9·24	·380	9·65	..	..	..	..
1/0	·324	8·23	·324	8·23	·340	8·63	..	..	..	..
1	·300	7·62	·289	7·338	·300	7·62	·004	·101	·227	5·757
2	·276	7·06	·257	6·527	·284	7·21	·005	·127	·219	5·558
3	·252	6·40	·229	5·808	·259	6·578	·008	·203	·212	5·380
4	·232	5·89	·204	5·18	·238	6·04	·010	·254	·207	5·257
5	·212	5·38	·181	4·59	·220	5·58	·013	·330	·204	5·181
6	·192	4·88	·162	4·11	·203	5·156	·013	·330	·201	5·105
7	·176	4·46	·144	3·66	·180	4·57	·015	·381	·199	5·048
8	·160	4·06	·128	3·24	·165	4·187	·016	·406	·197	4·997
9	·144	3·66	·114	2·89	·148	3·753	·019	·482	·194	4·921
10	·128	3·24	·101	2·565	·134	3·40	·024	·61	·191	4·845
11	·116	2·94	·090	2·28	·120	3·04	·029	·736	·188	4·777
12	·104	2·642	·080	2·03	·109	2·768	·034	·863	·185	4·697
13	·092	2·336	·071	1·79	·095	2·413	·036	·914	·182	4·620
14	·080	2·03	·064	1·625	·083	2·108	·041	1·041	·180	4·57
15	·072	1·828	·057	1·447	·072	1·828	·047	1·143	·178	4·513
16	·064	1·625	·050	1·27	·065	1·65	·051	1·295	·175	4·437
17	·056	1·422	·045	1·14	·058	1·473	·057	1·447	·172	4·360
18	·048	1·219	·040	1·016	·049	1·244	·061	1·549	·168	4·263
19	·040	1·016	·035	·889	·042	1·066	·064	1·625	·164	4·161
20	·036	·914	·031	·787	·035	·889	·067	1·701	·161	4·085
21	·032	·812	·028	·711	·032	·812	·072	1·828	·157	3·988
22	·028	·711	·025	·635	·028	·711	·074	1·879	·155	3·937
23	·024	·61	·022	·558	·025	·635	·077	1·955	·153	3·886
24	·022	·558	·020	·508	·022	·558	·082	2·082	·151	3·835
25	·020	·508	·017	·431	·020	·508	·095	2·413	·148	3·753
26	·018	·457	·015	·381	·018	·457	·103	2·616	·146	3·702
27	·016	·406	·0148	·376	·016	·406	·113	·87	·143	3·626
28	·0148	·376	·012	·304	·0148	·376	·120	3·04	·139	3·528
29	·0136	·345	·0116	·29	·0136	·345	·120	3·04	·134	3·401
30	·012	·304	·101	·254	·012	·304	·126	3·193	·127	3·217
31	·0116	·29	·008	·203	·010	·254	·133	3·376	·120	3·04
32	·0108	·274	·0079	·199	·009	·228	·143	3·626	·115	2·917
33	·010	·254	·007	·177	·008	·203	·145	3·677	·112	2·840
34	·009	·228	·006	·152	·0076	·192	·148	3·753	·110	2·79
35	·008	·203	·0056	·142	·005	·127	·158	4·013	·108	2·743
36	·0076	·193	·005	·127	·004	·101	·167	4·237	·106	2·692

WIRE AND SHEET METAL GAUGES—(*Concluded*)

Number of Gauge	*Lancashire Steel Wire Letter Gauge*		*London or Old English*		*Morse Steel Wire Gauge for Drills*		*Music Wire Gauge, English*		*Music Wire Gauge, Washburn and Moen*	
	in.	*m/m.*	*in.*	*m/m.*	*in.*	*m/m.*	*in.*	*m/m.*	*in.*	*m/m.*
7/0	..	..	..	..	..	..	..	..	·008	·203
6/0	..	..	..	..	..	..	..	..	·009	·228
5/0	..	..	..	..	..	..	..	..	·010	·254
4/0	..	..	·454	11·53	..	..	..	..	·011	·279
3/0	..	..	·425	10·787	..	..	..	..	·012	·304
2/0	..	..	·380	9·65	..	..	..	..	·013	·330
1/0	..	..	·340	8·63	..	..	..	..	·014	·355
1	Z ·413	10·48	·300	7·62	·228	5·783	·011	·279	·015	·381
2	Y ·404	10·26	·284	7·21	·221	5·60	·012	·304	·016	·406
3	X ·397	10·07	·259	6·578	·213	5·406	·013	·330	·017	·431
4	W ·386	9·80	·238	6·01	·209	5·308	·014	·355	·018	·457
5	V ·377	9·56	·220	5·58	·205	5·207	·015	·381	·020	·508
6	U ·368	9·34	·203	5·156	·204	5·181	·016	·406	·021	·533
7	T ·358	9·09	·180	4·57	·201	5·105	·017	·431	·023	·584
8	S ·348	8·83	·165	4·187	·199	5·048	·019	·482	·024	·609
9	R ·339	8·60	·148	3·753	·196	4·972	·020	·508	·025	·635
10	Q ·332	8·43	·134	3·40	·193	4·921	·022	·558	·027	·685
11	P ·323	8·17	·120	3·04	·191	4·845	·024	·609	·028	·711
12	O ·316	8·02	·109	2·768	·189	4·798	·025	·635	·029	·736
13	N ·302	7·67	·095	2·413	·185	4·697	·027	·685	·031	·787
14	M ·295	7·48	·083	2·108	·182	4·620	·028	·711	·032	·812
15	L ·290	7·36	·072	1·828	·180	4·57	·031	·787	·034	·863
16	K ·281	7·13	·065	1·65	·177	4·487	·0314	·797	·036	·914
17	J ·277	7·02	·058	1·473	·173	4·335	·034	·863	·037	·039
18	I ·272	6·90	·049	1·244	·169	4·288	·035	·889	·039	·990
19	H ·266	6·75	·040	1·016	·166	4·212	·039	·990	·041	1·011
20	G ·261	6·62	·035	·889	·161	4·085	·041	1·041	·043	1·092
21	F ·257	6·5	·031	·787	·159	4·038	·046	1·168	·046	1·168
22	E ·250	6·35	·029	·736	·157	3·987	·049	1·244	·048	1·219
23	D ·246	6·24	·027	·685	·154	3·911	..	..	·051	1·295
24	C ·242	6·14	·25	·635	·152	3·860	..	..	·055	1·397
25	B ·238	6·04	·023	·584	·149	3·778	..	..	·058	1·473
26	A ·234	5·94	·020	·508	·147	3·727	..	..	·062	1·574
27	..	..	·018	·457	·144	3·651	..	..	·065	1·651
28	..	..	·016	·406	·140	3·55	..	..	·072	1·828
29	..	..	·015	·381	·136	3·452	..	..	·076	1·930
30	..	..	·013	·330	·128	3·243	..	..	·080	2·03
31	..	..	·012	·304	·120	3·04	..	..	..	..
32	..	..	·011	·279	·116	2·942	..	..	..	..
33	..	..	·010	·254	·113	2·866	..	..	..	..
34	..	..	·0095	·241	·111	2·815	..	..	..	..
35	..	..	·009	·228	·110	2·79	..	..	..	..
36	..	..	·0075	·19	·106	2·692	..	..	..	..

TABLE SHOWING RELATION BETWEEN ENGINE REVOLUTIONS PER MINUTE AND SPEED IN MILES

Speed in Miles per Hour

Gear Ratio	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100
3	390	585	775	970	1165	1360	1555	1750	1945	2135	2330	2525	2720	1915	3110	3305	3500	2690	3885
3·2	415	620	825	1035	1240	1450	1655	1860	2065	2275	2485	2690	2895	3100	3310	3520	3725	3930	4140
3·4	440	660	880	1100	1320	1540	1760	1980	2200	2420	2640	2860	3075	3300	3520	3740	3960	4175	4400
3·6	465	700	930	1165	1395	1630	1860	2090	2330	2560	2790	3025	3260	3490	3720	3960	4100	4420	4660
3·8	490	735	980	1225	1470	1715	1952	2210	2455	2700	2945	3185	3435	3680	3925	4170	4420	4660	4915
4	520	775	1035	1295	1555	1810	2070	2330	2590	2850	3115	3365	3625	3880	4145	4405	4665	4920	5180
4·2	545	815	1085	1355	1630	1920	0170	2445	2720	2985	3260	3530	3800	4075	4345	4620	4885	5160	5430
4·4	570	855	1140	1420	1705	1990	2275	2560	2845	3130	3420	3700	3980	4270	4560	4840	5125	5410	5695
4·6	595	890	1190	1485	1780	2080	2375	2675	2975	3270	3565	3865	4160	4460	4760	5055	5350	5650	5945
4·8	620	930	1240	1550	1860	2170	2480	2785	3110	3415	3725	4035	4350	4660	4970	5280	5580	5900	6205
5	645	970	1295	1615	1940	2260	2585	2915	3235	3560	3880	4210	4535	4855	5180	5500	5825	6145	
5·2	670	1010	1345	1680	2015	2355	2680	3025	3365	3700	4035	4375	4710	5045	5380	5715	6060		
5·4	700	1045	1395	1745	2090	2440	2790	3145	3495	3845	4195	4545	4895	5245	5480	5945	6295		
5·6	725	1085	1445	1810	2170	2535	2900	3260	3620	3980	4340	4710	5080	5430	5795	6160			
5·8	750	1125	1500	1875	2250	2625	3005	3375	3755	4130	4510	4880	5255	5630	6010				
6	775	1165	1550	1940	2325	2715	3110	3490	3880	4270	4660	5045	5430	5825	6205				

This table relates to 26" Tyres. *For 24" Tyres multiply revolutions by 1·08.* *For 28" Tyres multiply revolutions by ·93.*

FACTS ABOUT BROOKLANDS TRACK

One circuit on centre line	2 miles 1,350 yards.
One circuit at 10 ft. from inner edge	2 miles 1,263 yards.
Width of track	100 feet.
Length of finishing straight	991 yards.
Maximum height of banking on shorter curves	28 feet 8 inches.
Radius at which curve of track is struck :—	
Byfleet Banking	1,500 feet.
Members' Banking	1,000 feet.
Mileage expressed in laps (on centre line) :—	
100 miles	36·14 laps.
1,000 miles	361·42 laps.
Surface length of Test Hill	352 feet. 3 inches.
Average gradient of Test Hill	1 in 5·027.
Maximum gradient of Test Hill	1 in 4.

BROOKLANDS DISTANCE TABLE

The length of the complete lap on the 50-ft. line is 2·76688 miles.

=4869·70483 yards.
=4.45 kilometres.

Laps	Miles	Laps	Miles	Laps	Miles	Laps	Miles
1	2·76688	20	55·33755	39	107·90823	58	160·47891
2	5·53376	21	58·10443	40	110·67511	59	163·24579
3	8·30063	22	60·87131	41	113·44199	60	166·01266
4	11·06751	23	63·63819	42	116·20887	61	168·77954
5	13·83439	24	66·40507	43	118·97574	62	171·54642
6	16·60127	25	69·17194	44	121·74261	63	174·31330
7	19·36814	26	71·93882	45	124·50950	64	177·08018
8	22·13502	27	74·70570	46	127·27636	65	179·84706
9	24·90192	28	77·47258	47	130·04325	66	182·61394
10	27·66878	29	80·23945	48	132·81013	67	185·38081
11	30·43566	30	83·00633	49	135·57701	68	188·14768
12	33·20253	31	85·77321	50	138·34389	69	190·91456
13	35·96941	32	88·54009	51	141·11076	70	193·68144
14	38·73629	33	91·30697	52	143·87764	71	196·44832
15	41·50317	34	94·07384	53	146·64452	72	199·21520
16	44·27004	35	96·84072	54	149·41140	73	201·98208
17	47·03692	36	99·60760	55	152·17828		
18	49·80384	37	102·37448	56	154·94515		
19	52·57068	38	105·14135	57	157·71203		

USEFUL FACTS AND USEFUL FACTS AND FIGURES

Bore and Stroke

BORE—Internal diameter of cylinder.

STROKE—Distance of sweep of piston from top position to bottom position.

Plug Points

As a rule the setting of plug points for the ordinary engine is one-fiftieth of an inch. Can be as much as one-sixteenth of an inch.

Tappet Clearances

The general practice is to allow three-thousandths of an inch clearance for the inlet valves and four-thousandths of an inch for exhaust value.

Compression Ratio

$$\frac{\text{Volume of space above piston at bottom of stroke.}}{\text{Volume of space above piston at top of stroke.}}$$

90 lbs. per square inch is the pressure often reached in the combustion chamber before mixture is ignited.

Piston Clearances

Cast-iron Pistons two-thousandths of an inch at skirt and three-thousandths of an inch at crown. With light alloy pistons, clearances depend on nature of material used.

Speed per Yard

Below will be found a useful table showing varying distances covered in one second and the corresponding speed in miles per hour :—

4 8/9th	yards	10 m.p.h.
9 7/9th	,,	20 m.p.h.
14 2/3rd	,,	30 m.p.h.
19 5/9th	,,	40 m.p.h.
24 4/9th	,,	50 m.p.h.
29 1/3rd	,,	60 m.p.h.
34 2/9th	,,	70 m.p.h.
39 1/9th	,,	80 m.p.h.
44	,,	90 m.p.h.
48 4/9th	,,	100 m.p.h.

General.

One cubic inch equals 16·4 cubic centimetres.

Ten pounds is the weight of a gallon of water.

Specific gravity is found thus :—

$$\frac{\text{Weight of body in air.}}{\text{(Weight of body in air—Weight of body in water.)}}$$

One gallon of petrol weighs approximately 7½ lbs.

One inch equals 25·4 mm. and a metre is 39¼ inches.

0 degrees Centigrade and 32 degrees Fahrenheit = freezing point, and 100 centigrade and 212 degrees Fahrenheit = boiling point.

Multiply number of kilometres by 5 and divide by 8 and you obtain distance in miles.

Similarly litres multiplied by 88 and divided by 50 are converted to pints.

The Admiralty Knot = 6,080 feet. One Knot = 1·1515 miles.

Velocity of Light—186,000 miles per second—nearly.

Velocity of Sound, in air—1,142 feet per second.

Area of a Circle—Diameter squared × ·7854.

Area of a Triangle—Base × half perpendicular.

To find speed in miles per hour when time for measured distance is known :—

$$\text{m.p.h.} = \frac{45 \times \text{distance in yards.}}{22 \times \text{time for distance in secs.}}$$

Engine Capacity = square of diameter × ·7854 × stroke × number of cylinders.

Formulae for H.P.

S = Stroke in centimetres.

D = Diameter of cylinder in centimetres.

R = Revolutions per minute.

N = Number of cylinders.

R.A.C. Formula H.P. $= \dfrac{D^2 \times N}{16{\cdot}13}$

A.C.U. Formula = 100 c.c. = 1 h.p.

A more accurate formula is the Dendy Marshall, in which—

$$\text{H.P.} = \frac{D^3 \times S \times N \times R}{200{,}000}$$

Firing Order.—If the timing of any motor is not known, it can be ascertained by following the action of the inlet valves, starting with No. 1 cylinder, then noting next inlet valve to open, as the engine is slowly cranked in nominal direction of rotation.

When turned in proper direction, the inlet valve will open immediately after the exhaust valve closes.

Cylinder Bores and Strokes in Millimetres and Inches.

An Approximate Guide for Comparison.

A Cylinder measuring :—

Millimetres.	Inches.	Millimetres.	Inches.
80 × 80 =	$3\frac{1}{8} \times 3\frac{1}{8}$	108 × 120 =	$4\frac{1}{2} \times 4\frac{3}{4}$
80 × 86 =	$3\frac{1}{8} \times 3\frac{3}{8}$	110 × 125 =	$4\frac{5}{16} \times 4\frac{15}{16}$
83 × 83 =	$3\frac{1}{4} \times 3\frac{1}{4}$	112 × 128 =	$4\frac{7}{16} \times 5\frac{1}{16}$
83 × 86 =	$3\frac{1}{4} \times 3\frac{3}{8}$	114 × 130 =	$4\frac{1}{2} \times 5\frac{1}{8}$
86 × 86 =	$3\frac{3}{8} \times 3\frac{1}{8}$	116 × 134 =	$4\frac{9}{16} \times 5\frac{7}{16}$
84 × 90 =	$3\frac{5}{16} \times 3\frac{9}{16}$	118 × 138 =	$4\frac{5}{8} \times 5\frac{7}{16}$
90 × 90 =	$3\frac{9}{16} \times 3\frac{9}{16}$	120 × 140 =	$4\frac{3}{4} \times 5\frac{1}{2}$
90 × 100 =	$3\frac{9}{16} \times 4\frac{5}{16}$	122 × 143 =	$4\frac{3}{16} \times 5\frac{5}{8}$
95 × 115 =	$3\frac{3}{4} \times 4\frac{9}{16}$	124 × 146 =	$4\frac{7}{8} \times 5\frac{3}{4}$
100 × 115 =	$3\frac{15}{16} \times 4\frac{9}{16}$	126 × 148 =	$4\frac{15}{16} \times 5\frac{8}{16}$
105 × 118 =	$4\frac{1}{8} \times 4\frac{5}{8}$	128 × 150 =	$5\frac{1}{16} \times 5\frac{15}{16}$

ERRATA ET CORRIGENDA

p. 1—ACCELERATOR, line 5. For "foot pedal" read "pedal."

p. 4—AMMETER, line 2. For "the amount of current" read "the rate of flow of current."

p. 28—*Brake Adjustments*, second column, last line. For "ground" read "drums."

p. 44—*Jet Arrangement*, line 1. For "The jet arranged" read "The jet is arranged."

p. 45—*The Straight Through Type*, line 6. For "drop of pressure" read "drop in pressure."

p. 51—CATALYTIC IGNITION, line 4. For "trued" read "tried."